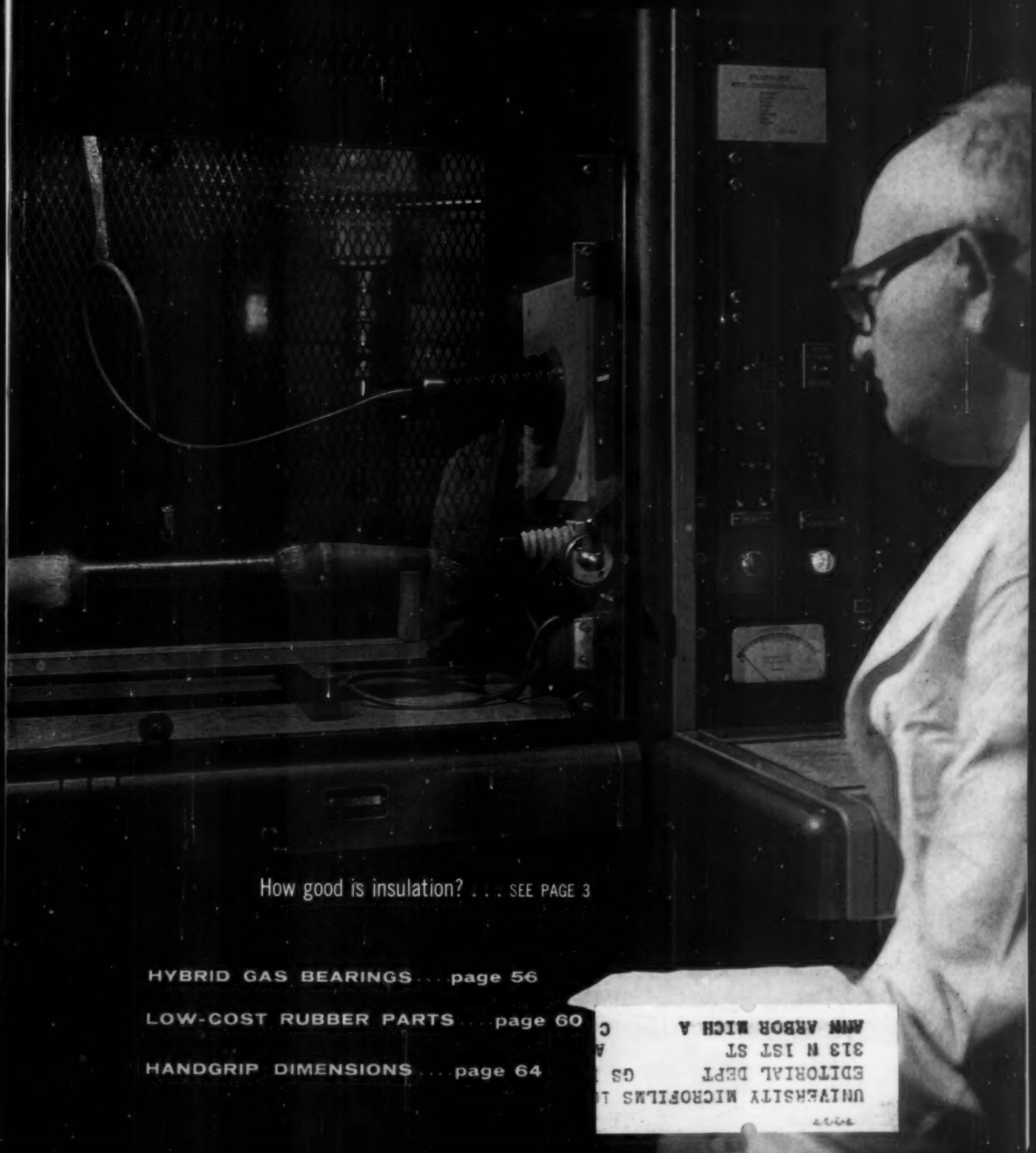
PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS APRIL 10, 1961



How good is insulation? . . . SEE PAGE 3

HYBRID GAS BEARINGS . . . page 56

LOW-COST RUBBER PARTS . . . page 60

HANDGRIP DIMENSIONS . . . page 64

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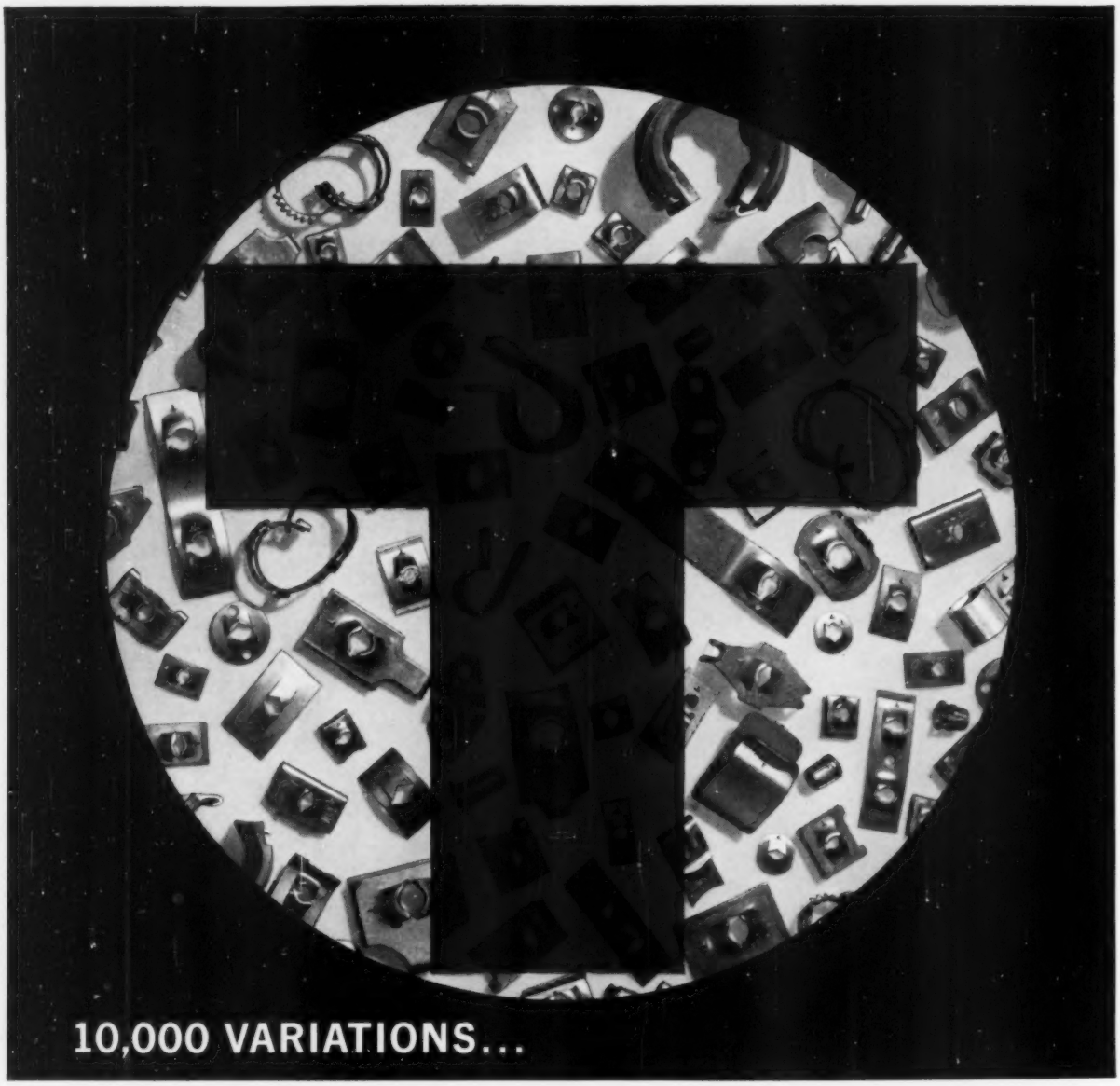

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

April 10, 1961 Vol. 32, No. 15

FEATURED:

DEPARTMENTS:

INTERESTING TO NOTE 3
WHAT'S NEW IN RESEARCH 6
DEVELOPMENTS TO WATCH 8
FROM WASHINGTON 12
THE ENGINEERING WEEK 15
POINTS OF VIEW 24
READER TO EDITOR 28
MEETINGS 31
FYI PERSONNEL 32
HORIZONS 39
PRODUCT DESIGN 52
DESIGN FILE 64
REPRINTS 66
SIGNIFICANT COMPONENTS 67
DESIGN LITERATURE 79
ADVERTISERS INDEX 88
READER SERVICE CARDS 89

CHOOSING THE RIGHT ELECTRICAL INSULATION . . . A J Sherburne
It's easier with this simple method, based on 2 comprehensive tables.... 41

HYBRID GAS BEARINGS ARE MORE STABLE . . . P H Stahlhuth
They benefit from hydrostatic flow and hydrodynamic design parameters 56

10 GUIDEPOSTS TO LOW-COST RUBBER PARTS . . . C H Yates, R B Bond
Specifying an elastomer? These rules will save time and money..... 60

DIMENSIONS FOR HAND GRIPS . . . F W Wood Jr
Here are most comfortable sizes for knobs and handles..... 64

FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MATERIALS:

Conversion coatings coming for zinc..... 8
Ductile palladium coatings promised by new plating techniques..... 9
Metal prices will be stable, says Battelle official..... 20
Self-bonding silicone rubber joins to ferrous metals..... 67

MECHANICAL:

Greaseless valve for vacuum work..... 6
New process improves lubricating oils..... 8
Multiple strikers do the job in French descaling tool..... 8
Nylon fastener designed in Britain..... 9
Model of new engine works, but..... 21
Teflon seal-ring needs less stretch to install..... 68

ELECTRICAL:

New semiconductor studied for ultrahigh temperatures..... 6
Improved semiconductors highlight IRE show..... 17
Limit switch has built-in neon lamp..... 67

PRODUCT DESIGNS:

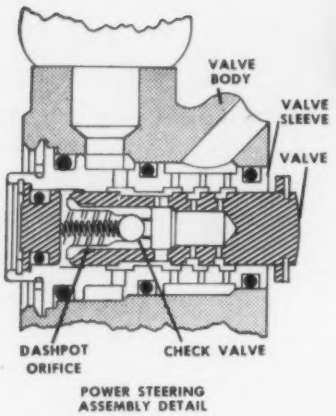
Exact speed is quickly selected by pushbutton..... 52
Geared tapes drive recorder..... 53
It measures strain at 5000 F..... 54

GENERAL:

Cover story—test machine measures voltage endurance of insulators..... 3
Automatic steam propulsion plant to be developed..... 9
Defense R & D to thrive under Kennedy budget..... 12
Court rules against FTC experts in water conditioner case..... 15

MINNESOTA MR RUBBER

FACTS for FILING on O-RINGS



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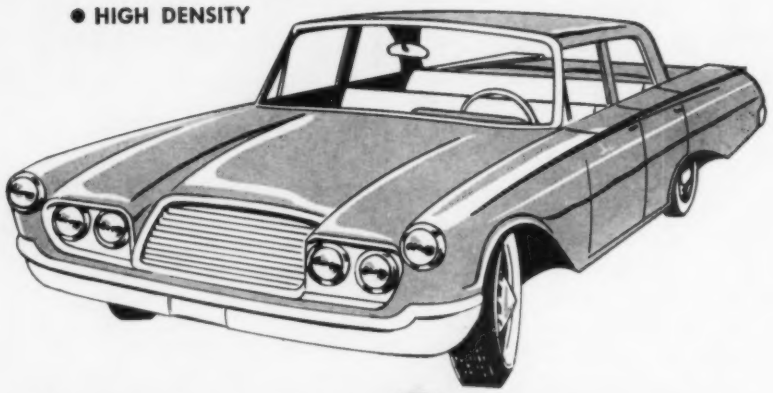
- EXCLUSIVE INJECTION MOLDED
- HIGH DENSITY



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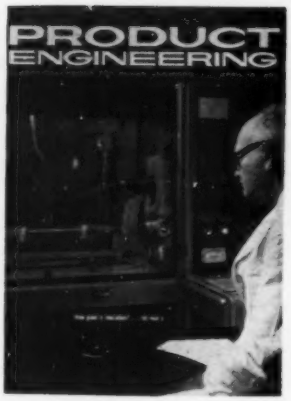

On our cover—test machine that measures the voltage endurance of insulating materials. This particular picture shows a cable at General Electric Co's laboratories undergoing a test at 25,000 volts. Very noticeable is the corona discharge. A special report on insulation begins on page 41. The problem of faulty insulation is a familiar one, and most dramatic when it creates a constant fire hazard. Several years ago, for example, it led to a fire beside some welding equipment at General Motor's Automatic Transmission Plant, Livonia, Mich. The fire might have been controllable, but the protective pan below the overhead conveyors was full of grease. Upon contact with a few sparks, this erupted into flames that quickly spread the fire throughout the building. The plant was razed and GM's production was seriously effected.

Overhead conveyers have always been hazardous. Until a few years ago, the overhead electrified monorail or crane was one of industry's most dangerous tools. Not only was it a fire hazard but lack of proper insulation caused an alarming number of fatalities. States such as California have enacted laws to ensure insulation of the wires.

Some people have tried better ways of insulation. A San Franciscan, Bruce Benbow, invented a trolley that made contact with the wire by a fitting that extended through a heavily sheathed conductor. The device was safe, but so complicated that it constantly broke down. Recently, the Insul-8 Corp, San Carlos, Calif, put a simpler device on the market. It consists of a trolley that makes contact by sliding along a protected slit in the insulation on the wire. This design also permits complex switching arrangements.

Storekeeper's Anniversary

Selling is not always limited to merchants. Sometimes an engineer is called upon to present his ideas before management. Whether or not an engineer must also be an "idea salesman" is therefore the subject of the debate on page 24.

Salesmen have been around for centuries, but selling as an art is a fairly recent development. One of America's great salesmen, John Wanamaker, began as a delivery boy in Philadelphia—delivering $3 suits in a wheelbarrow. One hundred years ago this week, he opened the doors of his first shop, selling suits for men and boys. One of the first day's sales totaled $24.67. Of this amount, he invested $24 for a newspaper ad and put the 67¢ in the drawer to make change the next day.

In some of his early stores he tried stunts that are

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legends today. One time a big gong was set up inside the front door to welcome each customer, make him feel important. The plan backfired. At the sound of the gong, some people were scared out of their wits—others were embarrassed and annoyed. The gong was removed. Also, posters 100 feet long were used each summer to stir up business. In a day when advertising was sedate and proper, Wanamaker sent balloons up from the store to announce that anyone who caught one and returned it could have a free suit of clothes. In 1888 he ran a full-page newspaper ad, the first ever tried by a department store, and his daily editorials in the ads were legend.

Shopping was tough a century ago, you had to traipse all over town to check off your whole shopping list. But

Wanamaker figured out a solution. He devised the first "composite store," forerunner of our department stores. As novel as the idea itself was the place he chose for his venture. He bought an old railroad freight depot in Philadelphia and in 1876 opened the Grand Depot, calling it "the store of a thousand surprises." More than 70,000 people crowded it the first day. Its counters (shown above) were arranged in a series of concentric circles, allowance was made for the weight of shoppers' bustles, bonnets and petticoats; and round-top stools around every counter helped to relax the shoppers.

Before 1866, customers and salesmen were engaged in a cold war—stores offered no guarantee for their goods, price tags were made for haggling purposes, clothes weren't sized accurately. You couldn't open a charge account, cash a check or return unsatisfactory goods. Then Wanamaker inaugurated the one-price system, with the amazing new guarantee of refunding money or exchanging goods "if they don't please the folks at home."

One of Wanamaker's biggest innovations was introduced during the Christmas season of 1878. For the first time anywhere, a store was lit by electricity. This caused so much excitement that Sunday papers actually demanded police protection for the public so they wouldn't be burned up inside the new-fangled store.

—Benedict A. Leerburger Jr.

SIDELIGHT

When the illness rate at Midland Mfg Co, Kansas City, Kan. dropped suddenly, the plant manager sought causes. The day the rate fell, the company had stopped use of an ultrasonic cleaning machine. Further investigation showed that vibrations in the inaudible range may have caused temporary illness akin to motion sickness. Reminds us that, some years back, Thompson Products was experimenting with ultrasonics, found that equipment had to operate at about 20,000 cps to be inaudible to workers. In the range of 20,000 to 30,000 cps, an added gain was the sudden disappearance of plant rodents—a happy finding tempered a few days later by neighbor complaints that all pet cats and dogs had gone as well. They couldn't stand the "noise." Suggests the idea that "sound" isolation may be the better part of valor.

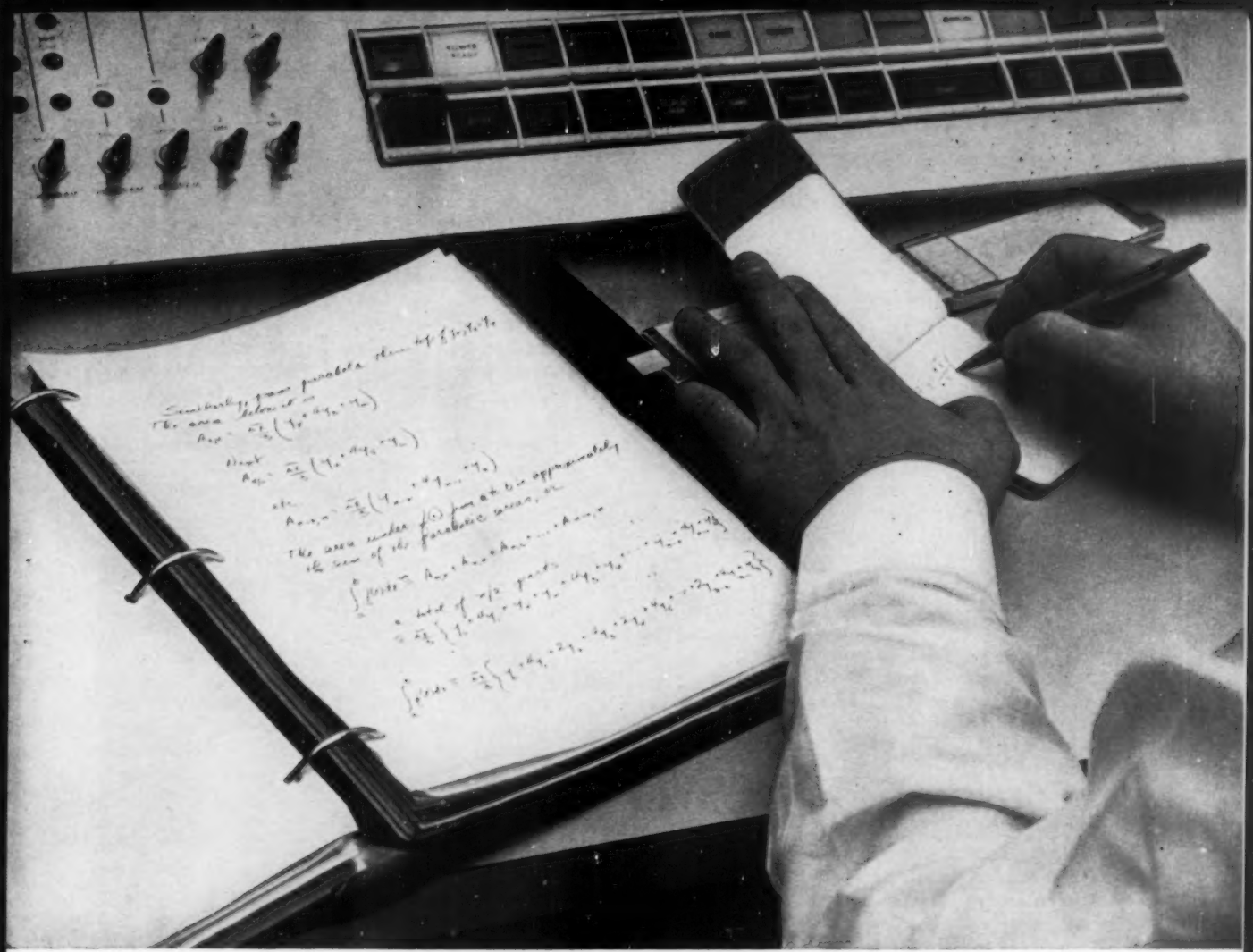
NEXT WEEK IN PRODUCT ENGINEERING

. . . **Your Selection Guide to High-damping Materials**
To control vibration in structures by applying viscoelastic materials, you must first know their dynamic mechanical properties. This Special Report gives basic data on over 50 important materials.

. . . **How to Analyze Deflection of Sleeved Shafts**
This practical method takes composite-beam theory a step further—it includes the effect of interference fits.

. . . **One-way Output from Speed Reducers**
When input reverses, these 5 slow-down mechanisms continue supplying a nonreversing rotation.

. . . **How to Pick the Right Mechanical Counter**
Don't rely on a last-minute choice from a catalog. Instead, design the entire system with the counter in mind. Here's the procedure.



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WHAT'S HAPPENING IN RESEARCH . . .

New ultrahigh-temp semiconductor?

Zirconium dioxide, at temperatures in the 2000-F range, shows decided semiconductor properties; and USSR scientists believe its heat resistance and high transparency in the 0.25 to 4-micron range make it of interest for electroconductive coatings.

Zirconia films, deposited on glass by vaporization of zirconium salts in humid atmospheres at elevated temperatures, or by hydrolysis of zirconium compounds, show a surface conductivity of 10^{-4} to 10^{-3} mho's and are transparent in the visible part of the spectrum. Treatment of the films with tin and bismuth can reduce the surface resistance still further. A report, by A. Y. Kuznetsov and L. A. Pafomova, appeared in a recent issue of *Fizika tverdogo tela*.

Fatigue effects of aluminum coatings compared

Sprayed metal coatings can improve both fatigue and corrosion resistance of aluminum alloys. But cladding lowers fatigue in air—often by substantial amounts—and is of only limited benefit in corrosion fatigue.

These are key points in a report prepared by E. A. G. Liddiard of Fulmer Research Institute for presentation at the current International Congress on Metallic Corrosion. The alloys tested were Al-Zn-Mg and Al-Cu-Mg compositions in sheet and rod form; and both the sprayed and clad coatings were pure aluminum, with the exception noted below. Tests were made under rotating cantilever, reverse bend, and axial push-pull loading, using 3% salt solution as the corrosive agent.

Effects of the sprayed coatings were not entirely beneficial. On the Al-Zn-Mg composition, under axial loading, spraying (with an aluminum-1% zinc composition) apparently reduces the air fatigue and does not significantly increase corrosion resistance.

(Note: For a report on earlier studies at Fulmer on the effects of sprayed coatings on steel, see *PE—June 27 '60, p 31*).

briefs . . .

Compression connectors are outlasting bolted connections in long-term weathering of aluminum conductors, O. A. Boyer of Central Power & Light Co reported to an AIEE regional meeting. A good many systems are now available to protect the conductors themselves. But exposure and weathering at connection points still pose problems; and choice of the right type of connection for each type of conductor can help a great deal. Alumium-sheathed, steel-core conductors seem to do best with compression connectors; while all-aluminum alloy conductors are recommended where both bolted and compression connection must be used.

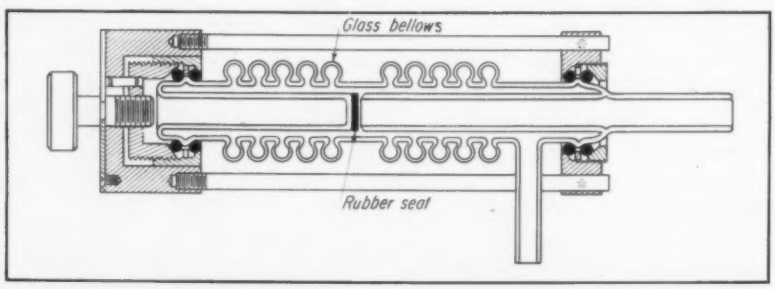
Stainless-clad zirconium may be the next step forward in nuclear reactor design. It holds the promise of providing structural and fuel-cladding materials that will have better strength and greater resistance to corrosion at higher temperatures. Says U. M. Staebler of the AEC's Div of Reactor Development: "A recently preliminary attempt to coextrude a one-mil clad of stainless steel on zirconium proved very successful. If this success is confirmed, it may permit the use of zirconium at higher temperatures in watercooled reactors."

Optimum thickness for rhodium plate varies by a factor of as much as 1000, Johnson Matthey (England) notes. To protect silver from tarnishing, as little as 0.000,01 in. of rhodium may be enough; while on heavily loaded wear surfaces, 0.001 in. may be needed. For light and medium loading, the range is generally 0.0001 to 0.0002 in. The high cost of rhodium, and the fact that the heavier coats (0.000,25 in. and above are more difficult to apply (they tend to develop hairline cracks), explain why selection of the optimum thickness is especially important. JM also warns that special precautions are required for depositing rhodium on aluminum and steel, both of which are attacked by the acid rhodium-plating bath.

Radioisotope handbook, with tables of half-life, conversion factors, and information on how isotopes are produced and used, is now available without charge to PE readers from Commercial Products Div, Atomic Energy of Canada Ltd, PO Box 93, Ottawa. It's a 64-page printed booklet (5½ by 8½ in.) that also contains good, brief descriptions of the fission process, types of radiation, and methods of shielding. —ARG

Greaseless valve for vacuumwork

With a glass bellows and a fluorine rubber seat, California Research Corp has designed a virtually leakproof valve for vacuum work on tetraethyl lead. An epoxy resin bonds the rubber (Viton A) to the glass stem. W. R. Doty and P. R. Ryason of California Research say the system operates smoothly, shows no leakage for periods of an hour or more at pressures of 0.1μ Hg. An alternate model with optically flat mating glass flanges for closure showed considerable leakage.



VACUUM VALVE features glass bellows, fluorine rubber seat. Rubber parts are shown in black. Metal parts are cross-hatched.

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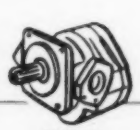

PUMPS

VALVES

MOTORS

CIRCLE 7 ON READER SERVICE CARD 7

DEVELOPMENTS TO WATCH...

New process improves lube oils

Oils that are less volatile and have higher viscosity indexes than conventionally refined motors oils, can be produced by a new thermal diffusion technique, Standard of Ohio's Research Dept says. The system promises better vacuum pump lubricants as well, and may lead to high-temperature (500-F range) lubricants with "superior oxidation resistance."

On the basis of limited fleet tests of thermal diffusion oils, G. R. Brown of Sohio told a recent meeting of the ACS Div of Petroleum Chemistry, it seems possible to reduce oil consumption by as much as 35% as compared to commercial 5W-20 oils, and achieve other benefits as well. Work is continuing—both on the properties of the oils and on the economies of the production technique.

Conversion coatings coming for zinc

Colored coatings for zinc, similar to those produced on aluminum by anodizing, are being developed and tested on a world-wide basis.

From Schering AG in Berlin, Germany comes news of a process which can be applied to galvanized coatings on any base metal, as well as to zinc parts. An American-sponsored project in Canada is working toward the same end.

Schering claims its process is simple and low in cost, uses standard equipment. After galvanizing, the metal is dipped (at room temperature) in a chemical bath, and then into one containing organic pigments of the desired color. Finally, it gets a coat of clear varnish. That's all there is to it. Experts here caution that, right now, such finishes are only as desirable as the varnish which covers them. A good deal of work is in progress on this score, though.

The Canadian program is specifically aimed at developing conversion coatings which won't need varnish protection, and US researchers are working on better varnishes.

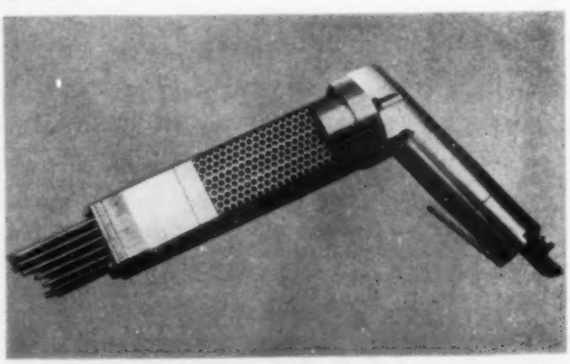
Self-bonding increases carbide strength 10-fold

Silicon metal in vapor form, generated as silicon carbide-graphite mixtures are pressed and sintered, can serve as a binding agent to produce strong, dense, impervious carbide parts, says British Ceramic Research Assn. Furthermore, the parts maintain their strength at temperatures close to 3000 F.

Both structural and electrical uses are foreseen for the self-bonded material since it has good thermal shock resistance and chemical resistance, a dielectric constant of 10.2 and a resistivity of 0.035 ohm-cm. Modulus of rupture is about 28,000 psi.

Multiple strikers do the job in French descaling tool

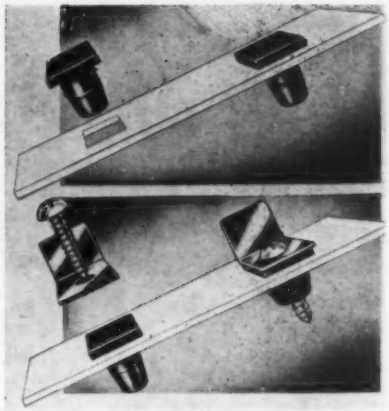
A pneumatic tool that descales by means of a bundle of movable spindles has been designed in France. Each spindle or striker is housed in a protective tube, and is topped by an adjustable, replaceable tip that can be designed to match the surface being descaled. The strikers and tubes are replaceable too, so length and diameter can be changed; also, the tube "bundle," handle, and working head are designed as independent units. The tool will operate from regular compressed-air lines. Air requirements are similar to those of a 5-hp compressor. Etablissements Barthod, 17-21 rue Barban, Lyon, Rhone, France designed it, calls it the "Airdecap."



IN NEW AIR-OPERATED HAND TOOL, distributor valve, housed in handle, feeds air to tube in which descaling strikers are housed. By controlling airflow, impact and frequency can be adjusted.

Nylon fastener designed in Britain

To provide a tough, vibration-resistant fastening system that will also offer electrical and chemical insulation, and can be inserted from one side, George Goodman Ltd of Birmingham, has designed the unit shown here. It's injection-molded in two forms—for square holes, as shown, or for round holes—with tiny underhead projections to help anchor it and prevent rotation. Prices will range between $5.50 and $9 per 1000 for standard sizes (¼ and ⅜-in. holes).



INSULATING FASTENER is clipped into position with the aid of small under-head projections, then held by screw pressure.

Automatic steam propulsion plant to be developed

Turning its attention back to the bread-and-butter ship-propulsion unit, the steam turbine, the Maritime Administration is sponsoring development of a plant that "will have a higher degree of mechanization and can be operated, controlled and maintained in a more efficient manner" than is possible with any units now in service.

The aim: to reduce operating costs and keep US competitive in world trade.

Design studies of the power cycle should be completed this year, and the Maritime Administration hopes to have a prototype built and installed in less than 24 months.

Ductile palladium coatings promised by new plating technique

Ductile, adherent palladium coatings can now be produced by chemical deposition, R. N. Rhoda of International Nickel Co reports. The process seems particularly promising for barrel plating of small electrical parts, and similar large-scale applications.

Dip-coating as well as barrel plating is possible; and coatings can be deposited on a wide variety of metals. Under some conditions, even nonmetal materials like graphite can be plated. As yet, though, it is not possible to secure direct deposition on copper. There are still problems, too, in solution control and plating speed. However, Inco believes these can be solved, and the process should be ready for commercial use before long.

New universal joint has "telescoping action"

A constant-velocity joint that also permits axial displacement is to be introduced by Con-Vel Div, Dana Corp. Balls, connecting the inner and outer members of the joint, provide for both torque transmission and axial displacement; and, says Con-Vel, greatly reduce the axial forces required for telescoping. Con-Vel also claims the new design is simpler and requires less space than previous units which had a splined member to provide the telescoping action. Prototype units are now under test, and additional information is to be made available shortly.

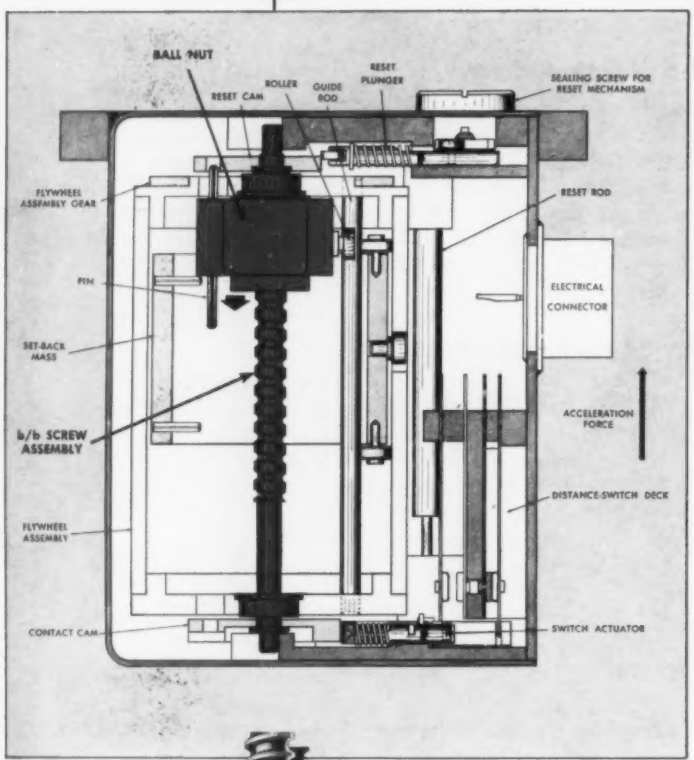
"Interlined" coatings tested for high-temperature protection

Heat-absorbing interlayers—intermediate coatings between base metal and surface layer—are under test at Watertown Arsenal Laboratories as a means for boosting the service temperature of structural metals. These interlayers would have heat absorption as their primary function, and would not be called upon to provide corrosion and erosion protection or structural strength. Those functions would be shouldered by the outer layer and the base metal. Among the combinations under test are high-strength steel and titanium as base metals; silver, copper and aluminum for the heat-absorbing layer; and chromium, chromium-nickel, chrome iron, rhenium, cobalt-tungsten, and platinum-group metals for the outer layer.

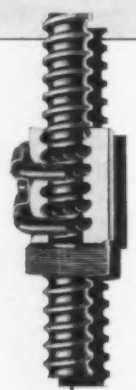
Tests thus far indicate copper interlayers, on the order of 80 mils in thickness, markedly increase the service time (period before a specified temperature is reached on the back of the metal) of specimens subject to flame-impingement tests.—**ARG**

When the Bird's on the wing

SAGINAW b/b SCREW HELPS INTEGRATE TIME AND DISTANCE FROM 2 TO 50 G's



Courtesy Integrated Dynamics Div., Globe Industries, Inc.



WRITE FOR OUR NEW DATA BOOK OR SEE SWEETS DESIGN FILE

Saginaw Ball Bearing Screws are highly efficient whether they are driving or being driven. A unique example is the way Integrated Dynamics Division, Globe Industries, Inc., Albuquerque, New Mexico, uses a b/b Screw.

First, the design problem: Develop a time-delay switching device which integrates the time function with missile's linear travel. The purpose is to safely arm the warhead. A strict "minimum G—time" system may arm a slow bird too soon for adequate protection of our own forces . . . and a fast missile may arrive before the warhead is fused.

Integrated Dynamics developed and builds the mechanical distance switch shown in the functional drawing to the left. The high-efficiency Saginaw b/b Screw is used to convert linear acceleration force into torque. Essentially proportional to the G-force, the torque of the b/b Screw is used to drive the flywheel mass. Flywheel energy, in turn, is used to actuate the arming switch through a cam.

The time required by the ball nut of the Saginaw b/b Screw to travel the length of the screw is also almost directly proportional to applied G-force. Thus, missile travel in distance is effectively integrated into a time delay which arms the warhead within a ± 5% of the desired distance on accelerations between 2 and 50 G's.

The Saginaw b/b Screw runs dry — without lubricants — in this application. Using the same b/b Screw, the switch gives repeatable distance accuracy of one percent. The screw is ground and electropolished to a surface finish of less than 5 microinches. The balls used are only one millimeter in diameter.

Whatever your actuation problem, chances are you can use a Saginaw b/b Screw to do the job efficiently. Why not write Saginaw b/b Screw and Spline Operation, Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan.

Saginaw ball bearing Screw

NOW AVAILABLE TO DESIGNERS AND PRODUCT PLANNERS

*PDCS

***PROTOTYPE DIE CASTING SERVICE**

A NEW PROCESS WHICH PROVIDES PROTOTYPE DIE CASTINGS WITHOUT HIGH COST TOOLING

What is PDCS?

Prototype Die Casting Service is a refinement and perfection of a plaster mold casting process which has been developed over a period of a year and a half of intensive research and test to a point which allows the low cost creation of simulated die castings, in small quantities, without the cost of conventional, permanent tooling. A Prototype Die Casting looks, feels, finishes and performs remarkably similar to a production die casting.

Why Was PDCS Developed?

The growing demands of designers, product planners, purchasing officials and sales management personnel prompted Newton-New Haven Company's development of the process. While the individual needs of all were different, the basic need behind them all was identical . . . a production method which would allow them to secure . . . each for their own reasons . . . small, low cost quantities of simulated die castings without underwriting permanent tooling charges.

How Can You Use PDCS?

If part of the product you are planning is to be a die casting and your customer requests samples before placing orders, PDCS can represent the solution to your problem. Or, if you wish to test the function of an assembly which includes a die casting . . . determine the strength of a die casting as applied to your needs . . . gauge the sales appeal of your product by sampling . . . judge the "feel" and appearance of a die casting . . . PDCS provides the means. If you are interested in holding down the cost of new product development and avoiding expensive design errors it will pay you to fill out the coupon in this announcement and mail it today as a first step in learning more about PDCS.

How Much Does PDCS Cost?

Very little compared to the advantages and cost savings PDCS can achieve for you. The factors determining cost are shape and complexity of the part as well as the quantity required.

How Can You Start To Work With PDCS?

If you have a part in design to which you believe PDCS may provide an answer and you have prints of the part to be Prototype Die Cast, forward the prints with an indication of the quantities you will require. A cost-estimate will be sent to you. Should you have a model of the part, but no prints, the model may be sent in for cost-estimating purposes. If you have just an idea about the part and not prints, sketches or models, a Newton-New Haven Technical Representative will call on you and assist in the development of drawings sufficient for cost-estimation.

From your prints, models, sketches or ideas, if part of your product is to be a die casting . . . start with PDCS

* *This name identifies an exclusive service of the Newton-New Haven Company, developed to serve the needs of Designers, Product Planners and others in industry interested in die castings as the quality method of mass production.*

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CUSTOM PRODUCERS OF DIE CASTINGS

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☐ Models ☐ Prints ☐ Sketches are being forwarded under separate cover. Please submit your cost-estimate.
☐ Have your representative call.
☐ Send me your free folder, "PDCS . . . Prelude to Production".

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COMPANY: _____
ADDRESS: _____

DIE CASTING RESEARCH FOUNDATION PARTICIPANT

NEWTON NEW HAVEN

FROM WASHINGTON...

Defense R & D to Thrive Under Kennedy Budget

President Kennedy has sent Congress a new budget that calls for increasing spending some $3 billion above Eisenhower's fiscal 1962 budget. The biggest chunk of new money, some $2.3 billion, will go for aid to schools, agriculture, unemployment, etc.

Defense spending will increase by $650 million and space efforts by $85 million in the coming year. Contract-letting from new appropriation requests, however, swells to around $1 billion for defense items and $126 million for space projects. Of this, over $400 million is for R & D.

Major changes for defense are: increase Polaris submarine authorization by 5 subs, bringing the total to 29 submarines either built or authorized. Speed up development of the A-3, 2500-mile Polaris missile by one year to have it operational by mid-1964.

The Air Force's Minuteman ICBM Program will shift three of its railroad mobile squadrons to fixed-base squadrons. This defers, but does not kill, the Mobile Minuteman Program.

Procurement money for the Air Force's air-launched ballistic missile, Skybolt, is doubled for a total of $50 million in 1962; $286 million will be used to accelerate work on the military space programs Midas, Dynasoar, Advent, Defender, Discoverer, and Samos.

Some $122 million extra will be pumped into research for conventional military weapons and $45 million to develop an advanced short-takeoff tactical aircraft.

Cutbacks in the Kennedy budget include canceling two squadrons of Titan II missiles; reducing the B-70 Mach 3 Bomber Program from 12 prototypes to 4 stripped-down prototypes. This amounts to a cut of some $138 million in 1962 and $1.4 billion long range.

The Military Nuclear Aircraft Program is canceled, but the Atomic Energy Commission will continue limited work on the project. Canceled, too, is the Navy's air-to-air Eagle Missile. The Missileer aircraft to carry the Eagle missile had previously been canceled by President Eisenhower.

NASA's increased budget will be split between R & D and increased facilities and personnel. R & D contracts will amount to about $100 million of the $126 million authorized for the Space Agency.

Accelerating development of booster rockets gets the largest chunk of the new money. Some $56 million will be used to lop one year off development time for the big, second-generation C-2 Saturn Booster, making it available around 1966. The Centaur Booster gets $25.6 million to speed its development. The liquid-fueled F-1, 1.5 million-lb.-thrust engine gets $9.3 million to make it available by 1965.

The nuclear rocket engine, Rover, gets a $14 million increase in funds. Some $10 million is added by the AEC and $4 million by NASA to make a total of $59.5 million for 1962. The new money will be used to accelerate reactor development and advance turbo pump and nozzle development.

Development of a Mach 3 commercial transport aircraft is earmarked for $16 million. NASA will fund $2 million with the Federal Aviation Agency, accounting for the balance.

There's an answer to *your* electric heating problems in Vulcan's versatile line of heating units, components, and equipment.

A wide range of sizes, types and ratings is available to meet a variety of heating needs: *cartridge heaters* for insertion into machine parts, dies, platens, molds, presses, etc; *tubular heaters* for clamping to metal surfaces, insertion into machined grooves or casting into metal forms and machine parts; *strip heaters* for space or conduction heating; *immersion heaters* for all kinds of liquids. And in addition to components, Vulcan offers complete units such as air duct and radiant heaters for comfort heating, as well as circulation and fuel oil heaters.

Rely on *Vulcan versatility* — in product, in engineering, and in service — for your complete heating needs. *Write for catalog.*

Versatility in Electric Heating

VULCAN ELECTRIC COMPANY • DANVERS, MASSACHUSETTS

SILICONE NEWS from Dow Corning

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POUR RTV

STRIP MOLD

POUR RTV

FINISHED PART

SILASTIC RTV SILICONE RUBBER makes precision molds in minutes

These photos illustrate how easily you can produce exact molds and prototypes in a matter of minutes, instead of days or weeks. The medium: Silastic® RTV, the fluid silicone rubber that vulcanizes at room temperature.

The beauty of this silicone rubber: you simply add catalyst, mix and pour Silastic RTV into or around the object you wish to reproduce. The fluid rubber flows into the tiniest crevices, fills voids in even the most intricate parts, and vulcanizes without heat to form a durable accurate mold.

The cured mold easily withstands 500 F temperatures. You can use it to cast a variety of plastics or low-melting alloys. Release is no problem. The firm but flexible mold made of Silastic RTV strips easily from metal, wood, plaster, plastic and most other materials. Store the mold; it doesn't change on aging (crack or check) and you can make exact reproductions months, or even years later.

Using Silastic RTV is the quick and economical method of preparing duplicates that match the original in every detail. May we assist you in adapting this new design and development tool to your special needs? Write on your letterhead for *free sample* and how-to-use information. **Address Dept. 7216.**

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THE ENGINEERING WEEK

Court Rules Against FTC Experts in Water Conditioner Case

CHICAGO—The long-contested Federal Trade Commission cease and desist order against Evis Manufacturing Co, for allegedly making false advertising claims about its water conditioner, has been voided by the US Circuit Court of Appeals. The unanimous decision was based on the fact that the FTC charges against Evis relied exclusively on technical evidence, disregarding the testimony of consumers.

The original action by FTC dates back to Feb 1954. The Commission then ordered the company to stop claiming that its water conditioner will make hard water soft, remove unpleasant odors, save soap, reduce the cost of heating water, leach out alkali and salts in soil and thus reduce the amount of water required for irrigation (*PE—Apr 27 '59, p 25*). In the interim, Evis has disputed the order before an FTC examiner and finally the Circuit Court.

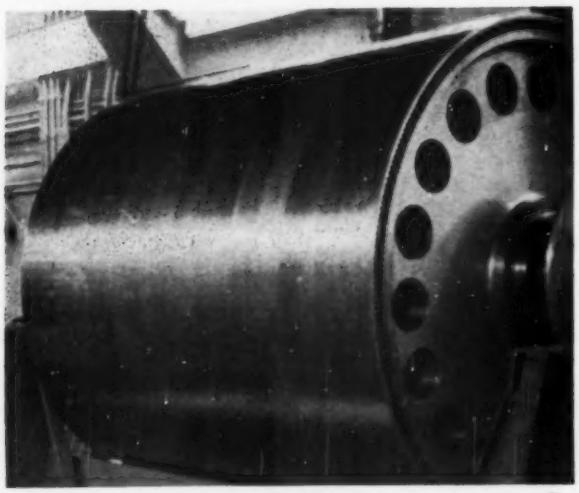
The Commission has based its case primarily on the technical evidence of experts. Those testifying included:

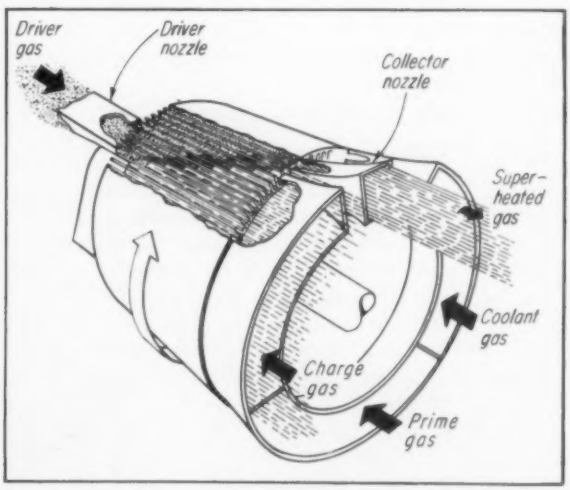
- Dr George D. Wagner, Jr, a spectrograph specialist from Washington State College, who asserted that he could find no difference in molecular structure of water treated by the Evis device and untreated water.
- Dr Mark F. Adams, a research chemist from Washington State, who, along with a colleague, testified that their tests failed to show any value to the Evis device.
- Dr Robert Weast, an associate professor of Chemistry from Case Institute of Technology, who said that the unit did not remove scale from pipes as claimed.
- Dr James Irvin Hoffman, chief of the surface chemistry section of the US Bureau of Standards, who said he could find no effect on water from the device.

Earlier, when the case was argued before an FTC examiner, Evis produced 91 witnesses who testified that they had derived benefit from the conditioner The examiner brought out the fact that 100,000 of the devices had been sold, and got the company to admit that roughly 3% had not performed satisfactorily. When the company subsequently appealed the case to the Circuit Court, the FTC tried to use this admission to show that some 3000 witnesses could be found who would testify that the conditioners were not satisfactory.

The court ruled that this was not admissible evidence, adding that the

Gatling-gun Principle Adopted for Hypersonic Shock Tunnel Rotor





Rotor for Cornell Aeronautical Laboratory hypersonic shock tunnel has 288 small slots, each serving as a shock tube, drilled around its circumference. Rotor was fabricated in three 22-in.-long sections. Holes 0.55 in. wide by 1.43 in. high were drilled in the rings simultaneously from both sides, and the rings bolted so that the slots are perfectly aligned. The precipitation-hardened stainless steel forging weighs 12,000 lb, is driven by a 1000-hp synchronous motor at speeds to 2700 rpm under a steady-state temperature of 700 F. During every rotation of the rotor, which takes about 22 millisec, each shock tube is cycled once with a charge. Driving, cooling and priming gases are supplied from nozzles around the periphery. Operation is as follows: A moving mass of high-pressure gas (the driver) slams through the shock tube, creating a shock wave in the low-pressure gas (the charge) already in the tube. The shock wave compresses the charge gas, heating it and forcing it from the tube. The compressed gas expands through a nozzle to the test section. Coolant gas cleans the tube and the prime gas brings the tube to a steady-state temperature. The system is designed to supply 4.3 lb per second of steady uncontaminated airflow at a stagnation temperature of 9000 R (about 8540 F) for expansion in a 50-sq-ft test section to Mach 15 for 15 seconds. Tunnel will permit testing almost full-scale aerospace craft, simulating heat flux at hypersonic speeds.

hearing examiner and the Commission were in error for basing their case on 3000 dissatisfied users, while disregarding the possibility of 97,000 satisfied users. The court further ruled that the Commission erred in giving no significance to the testimony of the 91 user witnesses.

Arthur N. Wells, inventor of the device, has never told how it works. He has maintained that he is applying for a patent and could not disclose the "secret" until he was protected. The Circuit Court agreed.

The Circuit Court at no time ruled on the merits of the device. Rather, it ruled on the legal aspects of the FTC's complaint, and found that the Commission had not presented enough evidence to substantiate its charges. The opinion was handed down March 6. The FTC has 90 days to decide on an appeal to the Supreme Court.

The Evis case is similar to an earlier FTC case against a battery additive, AD-X2. In that case the FTC itself, finally ruled in favor of the manufacturer of the additive, because there was some scientific evidence in favor of AD-X2.

In the Evis case, FTC has held, there has been no scientific support for the device. ■

Pratt & Whitney Sets Up Trade-in Plan

WEST HARTFORD, CONN—Pratt & Whitney has announced formation of a new machinery trade-in plan, which is said to be a first in the industry. Under the plan, the company will accept used or surplus machine tools of any manufacturer as part payment or a credit toward purchase of new Pratt & Whitney products.

The trade-ins will be handled through a separate corporate unit, the Machine Trading Corp. This new division will have facilities to warehouse, recondition and sell the machines taken on trade.

In describing operations of Machine Trading Corp, Paul Stanton, vice-president of Pratt & Whitney, emphasized that it will be an entirely separate corporate unit, but will work closely with the machine-tool division to give one-stop service to customers considering new machine tools. ■

CONTOUR CABLE (top) developed by Hughes Aircraft Co promises weight saving in aircraft and missiles. Flat cable embedded in plastic, says Hughes, can shape itself to any contour and even twist around obstructions; 1000 ft of conventional 20-conductor 22-gage aircraft cable weighs 82 lb while the same length of contour cable weighs 52 lb for the same current-carrying capacity. Conventional cable is 0.068 in. thick; equivalent contour cable is 0.013 in. thick. In lower photo the cable is shown in an interconnecting assembly for checkout equipment which carries 576 separate connections. In this assembly the cable takes a 90° bend and a 270° twist within 26 in. Assembly contains 16 cables (grouped in eight pairs) with 36 connections each. Pairs mate into a common insert card that contains 72 contacts, to plug into a double-readout printed circuit connector.

These Designs

PINLITES—low voltage, low current, microminiature incandescent lamps— are finding a variety of new applications such as at the tip of the pointer in the ammeter above. Kay Electric Co, Pine Brook, NY, reports lamps produce 60 millilumens at 3450 F filament temperature at a dc potential of 1.5 v at 15 ma. Dimensions—1/64 in. dia by 1/16 in. long. Life expectancy is over 1000 hr. Lamps can be pulsed at audio frequencies to full brightness or degrees of brightness.

Improved Semiconductors Highlight IRE Show

NEW YORK—The 850-plus exhibitors at the Institute of Radio Engineers Show drew a record attendance of 73,000 as engineers crowded through the doors of the Coliseum here, to inspect the latest in electronics goods. Booths were jam-packed from morning until night.

Biggest crowds were observed around the hi-fi displays by Knight, Heath and Eico, but even the industry giants, which had some of the smallest booths and leaned towards institutional displays, had their share of the crowds.

Modifications of existing components predominated, with little in the way of startling new equipment on display. As usual, "black boxes"—of all colors—abounded.

Semiconductor devices were everywhere, with major displays by Sylvania, IBM, RCA, Bell Labs, Merck, Texas Instruments, GE and many Japanese firms.

EPITAXIAL-GROWING FOR SEMICONDUCTORS

Big news here is the epitaxial-growing process which promises more versatile devices with better design features, fewer electrical components. The growing process differs from the standard method in that, after growth, the base material—silicon or germanium—is exposed to a vapor of the same element which results in a new growth giving the exact characteristics desired in the device.

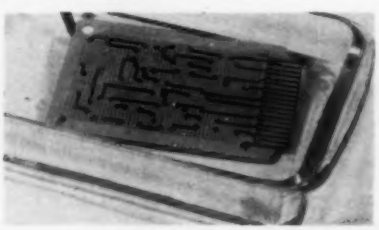
Using this process for semiconductor production, high-speed switching devices (twice as fast as at present) with unusually low saturation voltages and improved breakdown voltages are promised. In fact, Dr W. J. Pietenpol of Sylvania announced several new epitaxial diodes and transistors of both silicon and germanium for switching and amplification.

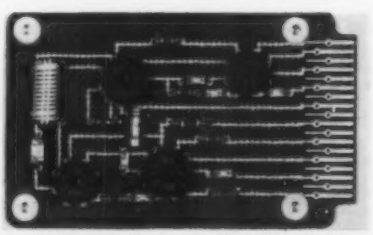
GALLIUM ARSENIDE IN PRODUCTION

One of the newer semiconductor materials is gallium arsenide, with several companies starting commercial production. Initial quantities of the material will find its way into high-temperature rectifiers, solar converters, microwave amplifiers and similar devices. Gallium arsenside differs from silicon and germanium in its improved heat resistance and its promise of higher frequency operation. But problems still exist, mostly in fabrication. ■

news continued on page 20

Applications Were Seen at the IRE Show





PROTOTYPE PRINTED CIRCUITRY can be made in office or lab in 15 minutes with Fotoceram grid boards by Corning Electronic Components. The 4 x 6-in. or 6 x 8-in. boards come with corner mounting holes and with or without a plug section. Designer dissolves the protecting lacquer coating and lays out circuit (left) between or over holes with liquid etching-resist from a tube, or with plastic resist tape. Two-sided circuitry with different or redundant patterns can be made because of through-hole metallizing. Where interconnection between the surfaces is not wanted, holes are left open. Copper not covered by resist is then etched away (center), leaving desired circuit runs and pads. Etching takes about 15 minutes, ends with a cold-water rinse. Components are next soldered to the board (right). Corning claims that units have been soldered and resoldered to circuit runs more than 50 times without damage to runs. Maximum operating temperature of the board is 480 F.

YOU CAN SEE THE EXTRA

DEPENDABILITY

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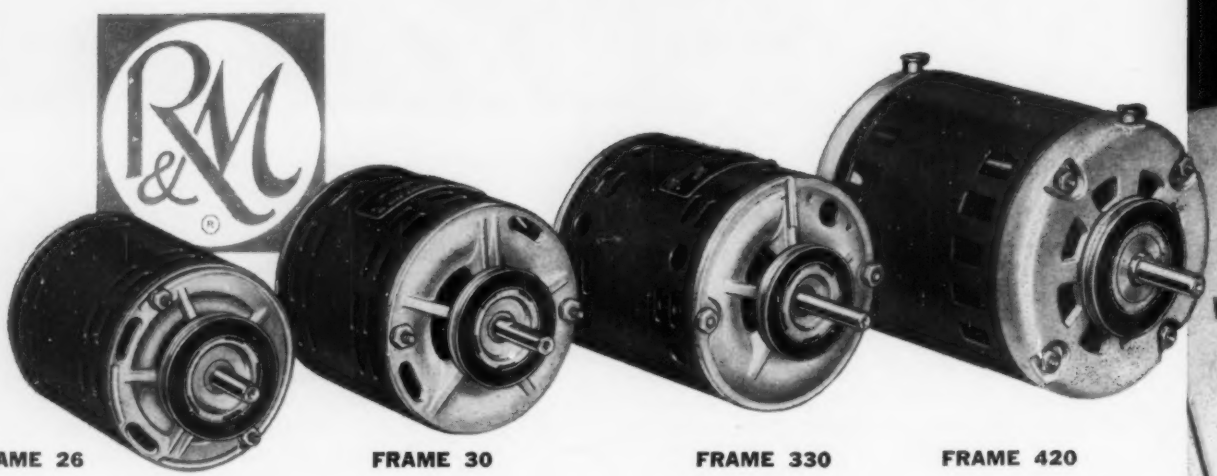

FRAME 26 FRAME 30 FRAME 330 FRAME 420

new broad line offers ratings from 1/100 through 1/3 hp!

R&M's Special Application AC Motors feature extra dependability for your customers and offer wide design flexibility to you! Silent operation, compact size and minimum maintenance make these FHP motors ideal for powering office appliances, fans and blowers, small motor driven tools and countless other products. You can select from four frame sizes, 3″ through 4¾″ dia.; sixteen ratings from 1/100 through ⅓ HP; two, four and six pole speeds; three mounting arrangements; and four electrical types—capacitor start induction run, split phase, permanent split capacitor or polyphase.

For long-life operation, Mylar is used to line the burr-free slot cells. Mylar has 8 times the dielectric strength of conventional insulation and stubbornly resists tearing and aging, to provide virtually permanent protection. Venturi baffles in each end head direct fan-driven air over and around coil ends in a "washing" action that quickly carries off heat, keeping the motor well within its rated temperature rise. The absence of centrifugal mechanisms and brushes further minimizes maintenance problems.

R&M Special Application Motors are available in standard off-the-shelf designs. Should you require a special custom motor, R&M will recommend the optimum design, at no obligation. Write today for new R&M bulletin 445-PRE

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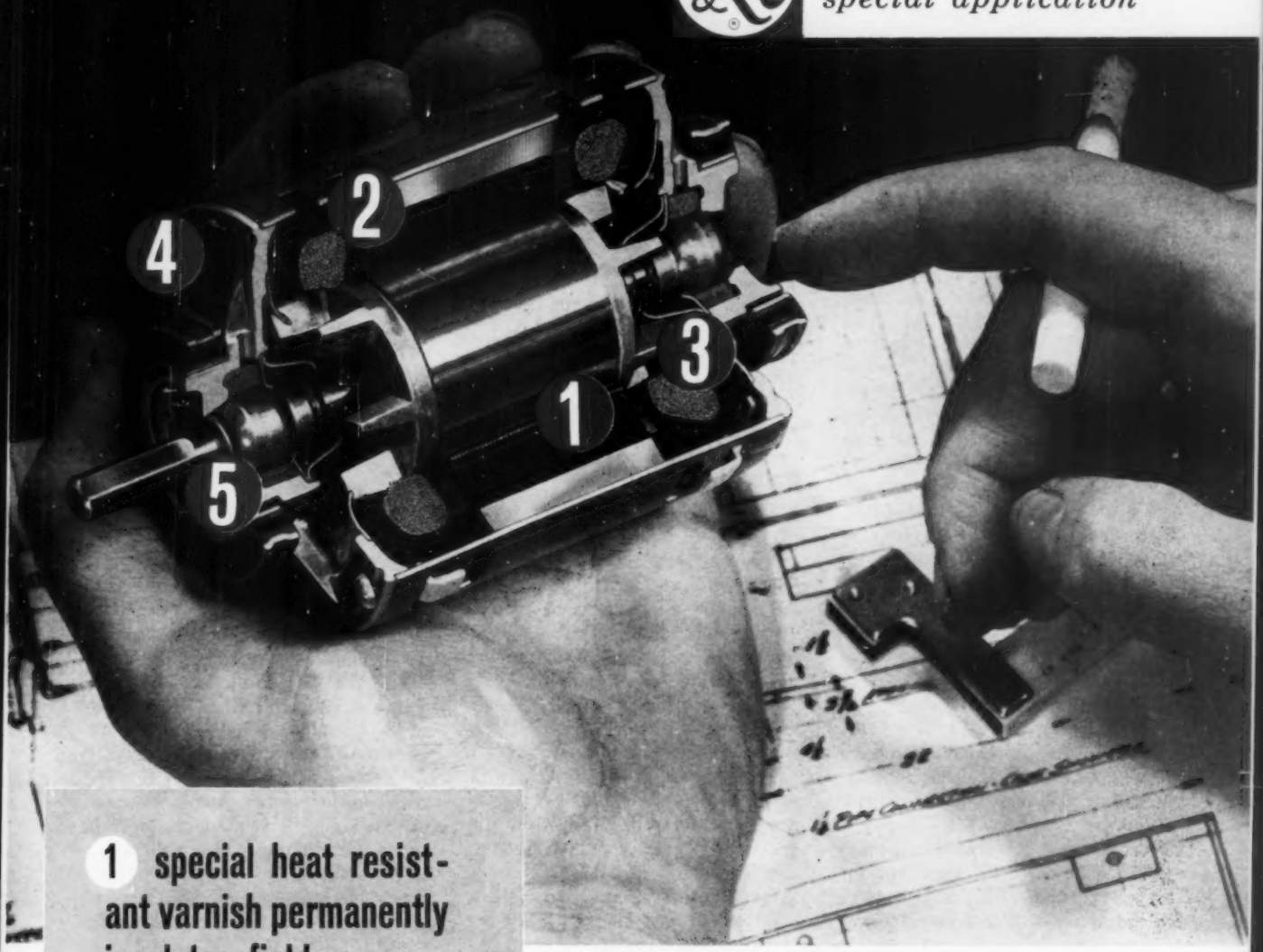
Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

R&M

FRACTIONAL MOTORS

special application



1 special heat resistant varnish permanently insulates field.

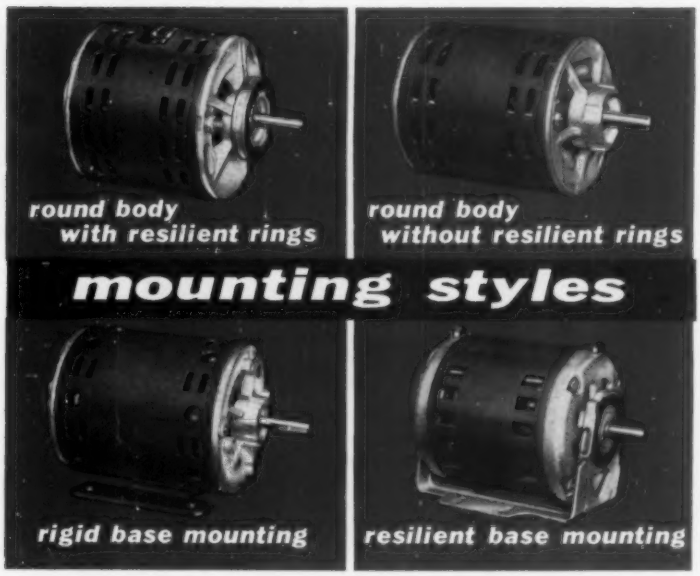
2 Mylar* insulation locked in burr-free slots.

3 high velocity air flow cools motor windings.

4 lightweight, die-cast aluminum end heads.

5 choice of sleeve or ball bearings.

*DuPont registered trademark.



CIRCLE 19 ON READER SERVICE CARD

news continued from p 17

Adult Science Program Gets NSF Backing

CHICAGO—The National Science Foundation has awarded the American Foundation for Continuing Education a two-year, $96,900 grant for continued development of an experimental study-discussion program designed to raise the level of public understanding of science. Heretofore, the AFCE has concentrated primarily on assembling materials for political education since its founding in 1948. But during the past year it has worked out the science program.

A test edition of the science program readings is now being evaluated by 5 pilot groups. Three are at adult education centers: Western Reserve, Cleveland; Oglethorpe Univ, Atlanta; and University College, Univ of Chicago. One is at the Oklahoma City Public Library and one is sponsored by two private citizens in Philadelphia. The NSF made its grant on basis of this test program. With this aid, the AFCE plans to reword its program and test it more widely next year.

The test program covers readings on such questions as: What are the human values of science? Is there a scientific method? Is there an order in nature that man can understand? Does the earth move? What is a scientific fact? Are scientific theories true? What is light? How was the universe created? What is man's place in the universe? What new horizons will be created by space? Readings cover such authors as George Gamow, James Van Allen, Sir James Jeans, Erwin Schrödinger and Bertrand Russell.

The materials will be used in study-discussion groups. Program participants are expected to do assigned readings during the week, then discuss them under guidance of a trained leader at class meetings. The leader is not necessarily a specialist in the discussion area.

AFCE expects to have some 50 to 75 discussion groups with 2000 to 3000 participants going this fall. Later, the organization hopes to start programs in physics, nuclear physics, chemistry and biology. ■

Semiconductor Institute Set Up in Japan

TOKYO—Sixteen Japanese electronics firms have founded a Semiconductor Research Institute (SRI) where the country's leading educators will do basic research in electronics with the emphasis on semiconductors.

Yasushi Watanabe, professor emeritus of Tohoku Univ, will serve as chairman of SRI's board, and Tomohiko Takano, also a Tohoku professor, will serve as president.

Tohoku professors will supervise research in the $149,000 institute, which will be built in northern Honshu, about 300 mi north of Tokyo by the sponsoring firms. ■

Battelle Official Foresees Long-range Price Stability for Most Metals

DETROIT—With one possible exception, relative cost of major metals in the next 10 years will not be affected by technological changes. That exception is the price of aluminum, which may be cut if new reduction processes now under test at Aluminium Ltd (Canada) and at Pechiney-Ugine (France) are successful.

This forecast by Dr Richard J. Lund, assistant technical director of Battelle Memorial Institute, was delivered to the 1961 SAE Production Meeting here.

However, Dr Lund warned that political changes might alter the picture, producing major shifts in the availability and cost of many metals and directly affecting a designer's choice of materials.

Least likely to be affected, according to the Battelle director, are iron and steel. Known reserves of iron ore in the US and Canada are more than ample to meet any foreseeable increase in demand. And recent technical developments permit sizable increase in productive capacity with limited capital expenditure. Also not likely to be affected are molybdenum and magnesium, as our domestic sources are ample to meet any expansion in demand.

Dr Lund was specific about the following metals:

Aluminum: reserves of high grade ore needed for the anticipated doubling of demand in the 60's are ample if the Caribbean area—Surinam, Jamaica, Haiti, and the Guianas—remain available.

Zinc: modest expansion in demand anticipated in the next 10 years. Large undeveloped reserves in Canada. Sufficient metal available to meet anticipated needs at prices near present levels, unless political developments were to cut off supplies from Mexico, Peru, or Australia.

Lead: outlook similar to that for zinc. Known supplies from North America probably ample, if necessary, to meet anticipated modest expansion in demand. Price may be higher if

Citroen Lifts Wraps on Its "Spacious Small Car"

Competition for world markets is breeding a rash of new European auto models. Citroen's latest entry, shown here, is the AMI 6. It is hinted to be less than 13 ft long, yet not really a small car. The AMI 6 will have front-wheel drive, powered by a 600-cc engine giving top speed better than 62 mph. Though price is still unannounced, the vehicle is scheduled for dealers before June. The car is being produced at the company's new Brittany plant.

political developments curtail or cut off supplies from Mexico, Peru, Australia.

Copper: ample supplies at prices close to present levels if supplies from Africa and South America remain available for Free World needs.

Nickel: loss of Cuban output has offset increases in North American supplies. Canadian ore reserves are ample, but more production capacity might have to be added.

Chromium: dependent on supplies from Southern Africa, which in the last couple of years has accounted for two-thirds of our needs.

Manganese: recent developments in Brazil lessen our dependence on sources from India, Ghana, Southern Africa.

Tin: tied up with availability from distant, politically uncertain sources in southeast Asia, Africa, Bolivia.

Antimony: from Mexico, South Africa and Bolivia. Large deposits in Alaska, but may mean higher price.

Tungsten: now obtained from Brazil, Portugal, and Korea. Large reserves in Canada will start coming into the market in 1962. Should we resume trade with China, the metal would be available in much larger quantities at or below present price. ■

–Felix Giordano, Regional Editor

Retired Engineers to Staff New Lab

BUFFALO, NY—A research and development center, staffed entirely by retired or semiretired engineers, will be opened soon at Boca Raton, Fla. The lab will be a facility of Scott Aviation Corp and will be headed by Frederick Flader, a former Buffalo engineer now living in Coral Gables. Flader has been director of the engineering lab at the Univ of Miami since 1958.

Retired mechanical and aeronautical engineers, who have been hired for the new center, will work only four hours a day, according to Earle M. Scott, president of the company. The short day was decided upon, he says, "because we want to keep the pace leisurely."

A $75,000 research center is now under construction in Boca Raton. Beside the lab and development facilities, the building will include a show room for Scott products. Work will be in product development. ■

Model of New Engine Works Fine, but . . .

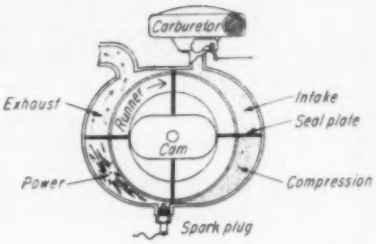
VIENNA—Another exotic powerplant has been designed in Europe, this one a wobble-piston engine. Leopold Brunner, a tinkering mechanic here, has a small operating prototype but a good number of questions are left unanswered by Brunner's carefully worded explanation to a PRODUCT ENGINEERING editor.

Engine, according to sketch (right) and the inventor's explanation, operates on the four-stroke principle. An oval housing contains a center-mounted cylindrical runner. Four axial grooves are machined into the runner, each serving as a guide to closely machined sealing plates. A center-mounted cam is housed inside the runner; the cam extends or retracts the sealing shields.

ENGINE IS NOISY

Prototype uses two-cycle engine fuel (gas-oil ratio is 20:1). Each chamber, formed by corresponding seal plates, is 1.4 cu in.; total engine displacement is about 8.5 cu in. The aircooled engine has a 7:1 compression ratio and delivers, according to Brunner, 10 hp at 3000 rpm with a peak at 5000 rpm. Total weight including carburetor and spark plug, but excluding fuel tank, is 15.4 lb, according to inventor Brunner.

The inventor is more than willing to show the starting and very noisy operation of the engine. Brunner will not say, however, how many hours the engine has run, what seal problems he has had, or what effect scale factor will have.

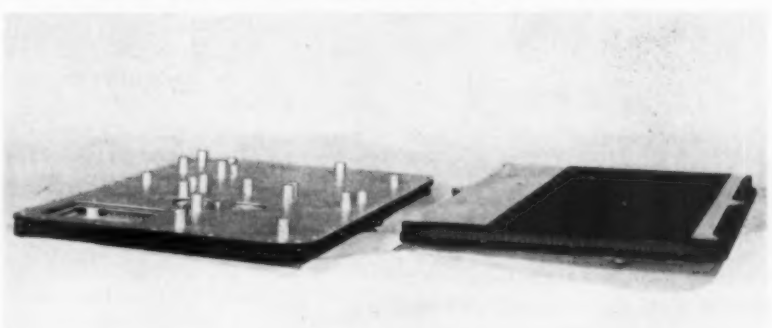


ARRANGEMENT of wobble-piston engine

In cautiously chosen words, Brunner indicates the gas-oil mixture is needed only for starting a cold engine; once operating, any fuel can be used. A second model, he says, will have sectioned plates instead of cast iron sealing plates, but no details are given. He is also working on a novel self-ignition scheme, which will use the flames of the power stroke to bring the following compression chamber to its ignition point. The flames, according to Brunner, pass through the sealing plate separating the chambers.

–Fred Baer, Regional Editor

Heat Sink Obtained from Dyna-damped Panels



A corrugated cold-plate radiator for cooling is sandwiched between these two 3-ply Dyna-damped panels to give a combination of mounting surface and heat sink. These panels are used as covers or access doors for pulse beacon radar systems on ICBM applications. Use of the panels, manufactured by Lord Manufacturing Corp, with their high damping characteristics results in a lighter, smaller unit with controlled structural response that achieves high reliability. For additional details on damping, see next week's issue of PRODUCT ENGINEERING.

Are your "dead storage" files more efficient than your active drafting files?

No doubt about it—it's important to keep correspondence carefully filed; *but* it is even more important to equip your drafting department with modern filing facilities that keep active and semi-active drawings readily accessible, fully protected—and in a minimum of space.

Your draftsmen, your productivity, deserve new Hamilton space-and-time-saving equipment—from Dietzgen

Inadequate or antiquated equipment in your drafting room *can cost you more money* than you imagine in lost time, errors, done-over work, and low morale. Hamilton equipment is *engineered* to fit your needs. It is *designed* to improve the practical, day-to-day creativity of your engineers or draftsmen. Its performance has been tested and *proved* in many thousands of installations. Our designers will gladly assist in the planning of your department. No obligation, of course.

HAMILTON UNIT SYSTEM FILES The Hamilton system offers maximum protection and capacity in minimum floor space. Each drawer of the patented shallow drawer units is equipped with a tracing lifting mechanism. Every tracing becomes a top sheet, instantly accessible. Unit sections can be assembled in a number of arrangements, stacked safely to any practical height. They stand up to hard usage, perform perfectly year after year.

Hamilton L-Contour Table
Prestige-assured, individualized work area providing complete board adjustment plus extra storage and reference area.

Hamilton CL 100 Drafting Table
Conserves dollars, yet rugged canted-leg design provides modern styling and convenience with long-term durability.

Hamilton Auto-Shift Table
Built-in mechanism adjusts board to individual height and slope requirements, provides full accessibility, reduces errors.

Drafting-Printmaking Booklet reports new techniques for solving engineering and production problems

This new 36 page booklet describes a wide variety of engineering and production problems that have been solved with advance techniques in drafting and printmaking pioneered by Dietzgen. The concise, problem-solution approach suggests ways in which you may improve the efficiency within your engineering department or eliminate production bottlenecks. Write today on your company letterhead for the Mechanics of Modern Miracles. Ask for Publication SPD2-A10.
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Fractional Horsepower Motors

Lamb Thinking on Universal Motors for a unique actuator application

Here's what Lamb Electric designed into these motors:

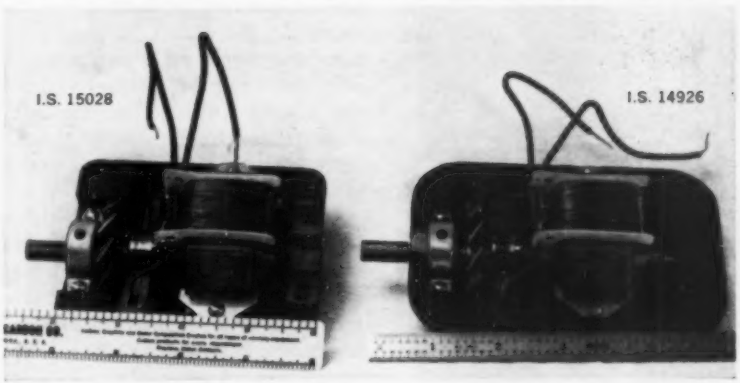
In order to obtain the required speed and torques and retain the most economical and smallest package, a combination worm and spur gear reduction was used. Also, because of the peculiar space limitations in the application, special design considerations had to be given to the gear ratios and mechanical layout of the package.

In the initial stages of the design a motor was provided which met the specified speed and torque requirements, however it was soon discovered that this design overheated rapidly. Analysis of the first prototype tests showed that the load cycle had a particularly high torque peak for a very short duration. The motor was designed to supply this amount of torque near its stalled speed. It was found that by taking advantage of the accelerating rate and starting torque of a universal motor, the motor accelerated quickly enough to provide sufficient inertial energy to complete the duty cycle. This enabled the engineers to redesign for a lower peak horsepower output and obtain reasonable operating temperatures, thus producing the minimum size package consistent with the torque and temperature requirements.

The application was such that severe shock loading was encountered at a certain point in the duty cycle. In order to make mechanical construction that would withstand this service, ductile iron castings were furnished and special consideration had to be given to the overhung moment of the motor-gear unit to insure against damage due to vibration. Special bearings had to be used in this service because Brinnelling would occur on normal ball bearings under the severe service encountered. Lubrication is generally a problem under this short duty cycle, therefore, special consideration had to be given to insure that the lubricant protected the wearing surfaces at all times.

This is just a short example of Lamb at work . . . if you have a motor problem, let us help you with it. This is our business. Write: Lamb Electric, Kent, Ohio, and we'll have a Lamb District Engineer call on you to open preliminary discussion of your problem.

THE LATEST DESIGN NEWS ON FHP MOTORS FROM LAMB ELECTRIC



New Lamb motors represent advancements in small universal motor design

New design combines high quality and long life with relatively low manufacturing costs

Initially, the I.S. 15028 and companion motor I.S. 14926 were designed for powering rug agitators on a well-known line of canister-type vacuum cleaners. Now, many future appliance applications have been visualized. The range of ratings possible with this design (as high as 1/10 H.P. at 12000 RPM or ⅛ H.P. at 15000 RPM) makes this motor ideally suited for many motor powered domestic applications.

Some of the novel features of this motor project were:

The housing is a one-piece simple phenolic molding. It is designed in a half shell form in such a way that the motor bearings and other components can be held in accurate relationship with an unmachined housing.

The half shell housing of the motor is designed to mate with a corresponding opening on the customer's device to complete the motor enclosure. When a free standing motor is desired, this upper enclosure can be a simple stamping.

The I.S. 15028 motor was designed with a sleeve and a ball bearing. However, on other versions of this motor, either sleeve or ball bearings or a combination can be used at only a low tooling expense through use of easily interchanged inserts in the housing mold cavity.

The sleeve bearing as used in this design takes full advantage of the economics possible with the half shell motor design. The full-spherical shaped self-aligning type of sintered bearing is mounted directly in a semi-spherical recess in the housing. A spring clip presses against the top of the bearing to secure it in place while at the same time permitting self-alignment movement. Life-time lubrication is provided by an oil soaked felt strip located beneath the bearing. There are other features worth noting in this unique design problem. For further particulars, write to Lamb Electric Co., Kent, Ohio.

POINTS OF VIEW

THE QUESTION:

Must Engineers Also Be Idea Salesmen?

FREDERICK K DAGGETT
President
Flexible Tubing Corp

Basically no . . .

The engineer should rather be an idea surgeon, subjecting his own ideas, and those of others, to a cold appraisal, to cut out the nonessential, to reshape an idea into an end result that has specific functions and uses.

When a corporation hires an engineer, for an engineering job, it is for his technical and analytical skills. This is not to say that the engineer need not be imaginative or creative. He must be both in initiating and developing new products, processes, formulas, or new applications for existing products. He must therefore be primarily an idea man, an "imagineer." However, his presentation to top management should be given as a cold statement of fact, devoid of showmanship and embellishments which a good salesman would naturally use.

The latter reason is why it is not particularly sound for the engineer to qualify as a salesman . . . at least in his internal dealings within a corporation. The engineer must preserve his objectivity at all costs, while the true salesman must necessarily be biased and prejudiced in favor of the idea or product he is selling at the moment. He cannot be truly objective. He would be a poor salesman otherwise. For the engineer to utilize the techniques of salesmanship in his presentations to management would mean that he has diluted his analytical value to the corporation.

If an engineer is expected to be an idea salesman, his impact on management becomes proportional to his sales ability. And if that is the case, too often a top-flight engineer who is a poor salesman would see his ideas passed over while an inferior engineer with good sales talent would see his ideas accepted—which in the long run would be to the over-all disadvantage of the corporation. It is a prime requisite of management to expect its engineers to be just that and not salesmen. On the other hand, management does not expect the engineer to be just a tool—one who will sit and wait for others to create ideas before getting into the picture. Development of ideas is a two-way flow with both top management and the engineering department responsible for idea creation and development.

Engineers with twitching noses

At Flexible Tubing Corp we expect our engineers to have the "twitching nose," as we call it. That is the ability to seek out new materials, new products, new developments. We expect the engineers to take ideas that are generated from any source, including themselves, and subject them to a thorough schedule of examination and analysis. We then expect them to present their findings to management in a concise, unbiased manner, along with their recommendations as to the advisability of further development and possible end uses. Our management neither expects nor needs a "sales" presentation. Salesmanship, we believe, should be reserved for the prospective customer. If management were to be swayed by a sales presentation on a new idea there would be grave questions concerning the final merits and actual profit possibilities inherent in the resulting product. Management, under the influence of a strong sales presentation could, in turn, lose its objectivity and produce an item of low marketability, and low contribution to earnings.

Ideas from three-way team

Our own company works on the principle of a three-way team—management-engineering-sales. All are responsible for ideas. But it is the engineer's function to analyze, test and develop. It is management's function to pass judgment on over-all practicability of the idea, its marketability, its cost structure and expected contribution to profits. The sales department must present the sales possibilities and, once the item is placed in production, carry through and move the product to the potential customer. All three work together but only the salesman may lose his objectivity during the process.

This is not to say that the engineer should not be a good verbal or written communicator. In fact, judging from what we have seen of recent engineering graduates, too little time has been devoted to this subject. We do require an engineer who is able to present his views, his ideas, his findings in a lucid, logical manner without any excess or extraneous verbiage. Finally, we believe that if the engineer feels he has to "sell" management on an idea, or new product, then management has failed in its responsibility and has lost the cold, objective viewpoint necessary to a sound evaluation of the possibilities and potential that may be inherent in the idea or proposed product.

GEORGE N KAHN
President
George N Kahn Co Inc
Market Development Specialists

I think he should . . .

An idea is the very substance with which an engineer must earn his living. Because he is a creative individual, he will think up new approaches—a new way to wire a motor, a better way to cast a steel part. But having these ideas is not enough; they must be implemented. Herein lies the problem with too many creative people. They spend months, even years, transforming an idea into a workable, patentable and even salable product, but when it comes time to present their work before those who must decide its fate, they lack the creativity to do a decent job of selling. They should have a well-rehearsed sales strategy. In other words, when it comes time to make the sales presentation it would be better if the graduate engineer acted more like a graduate salesman.

A company that exists solely upon a stale manufactured product is paving its own road to destruction. Too many sales departments don't want the new; they want the easy. It's therefore simpler to turn a deaf ear to the engineer who has a new-product idea, or quickly turn him aside with a hasty "not exactly what we need; keep working on it." The decision to commence a new-product venture is often left to a sales department when it should be in the hands of higher management.

The company engineer or engineering consultant, on the other hand, is faced with the problem of selling ideas to a management that doesn't always want to listen. It's unfortunate that an engineer will spend years and years in school learning his profession, then more years at a bench researching a particular project, and then be willing in a matter of minutes to try to explain his work to a superior who hasn't the foggiest idea about what is being said. No wonder the idea is rejected—it's not presented properly. The engineer has to know as much about selling his "ideas" as the company's salesmen know about selling a product. In many cases design ideas never reach their maturity because the engineer's presentation technique is out of date.

How to sell an idea

To begin with, the engineer who has developed a better mousetrap must understand the problems of all those who will pass on the merits of his brainchild. If the company's comptroller will be called in, prepare a study on how the new product will help him solve his problems.

The idea salesman must be an analyst as well as an able tactician—a one-man task force, so to speak. He must approach an executive in terms of the company's over-all objective rather than in terms of a specific product idea. The idea salesman must establish, with these executives, a relationship in which he is recognized as a source of possible help in solving over-all company problems. To achieve this, he must be capable of understanding his prospects to the degree that he can communicate both his appreciation of management problems and an image of himself as a source of help.

To accomplish this, the man with an idea to "sell" must motivate prospects to change by helping management become aware of a need for change. He must develop an appetite in management, even when it is not hungry, by fostering a constructive discontent with things as they are. Since most management people are generally satisfied with their present behavior, the idea salesman must disturb the prospects' satisfaction with the status quo.

First, however, the idea salesman must be brought into contact with a responsible representative of management. In most companies there is a chain of command. Therefore, learn the proper channels of communication and how to use them. In organizations, bypassing channels of communication is a very dangerous and usually unprofitable business. Not only will the people between the president and the design engineer have their backs up at once and be willing to kill off the idea, but they will go after the scalp of the person who has tried to eliminate the established channels of communication. If, of course, the engineer should "happen" to meet a board chairman or company president on the golf course or at a cocktail party, there is nothing to prevent his presenting his new idea. However, the same risks are involved in this approach as in going directly over a superior's head.

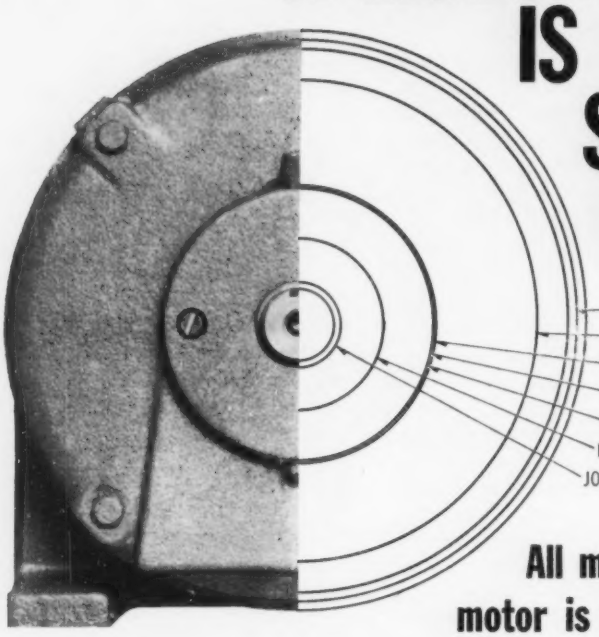
That all-important presentation

Next, the presentation itself. It must first include a full discussion of the problem. What is the present situation? What should be done to improve it? Know all the facts and be prepared to answer all questions. When you've reached the height of your sales talk, present your solution, your idea. Your presentation should include all the reasons that led you to research the particular product. Don't be afraid to be dramatic. In many cases a good salesman has to be a good actor. He must know his play, his lines and his audience.

When the time comes for management to ask questions, welcome them. Be grateful for that curve ball that is thrown to force you off balance. Catch it and fire it back. Learn the art of holding your ground and be prepared for questions of all sorts. Memorize your presentation and deliver it aloud before a mirror, first assuming that you're on a golf course with the company comptroller and again assuming you're in the office of the vice-president in charge of sales. Dry-run your idea with every man who could possibly have a voice in accepting or rejecting it, and accept the hurdles in presenting your idea the same way you accepted them in designing it.

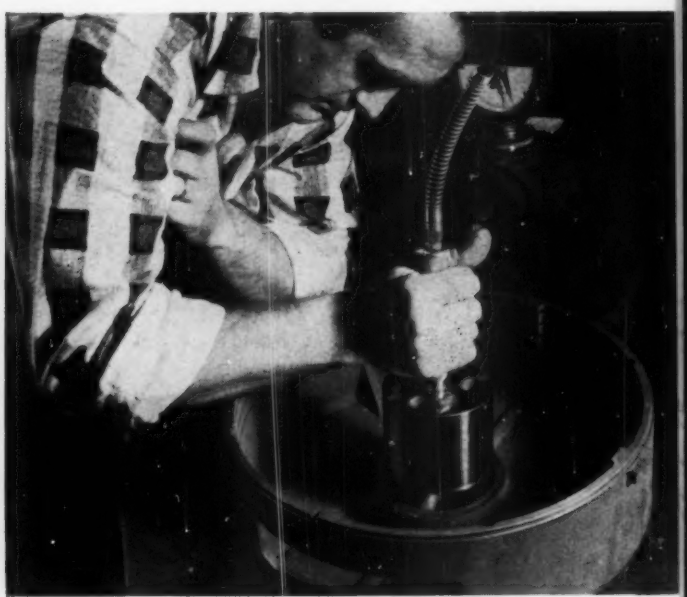
Don't feel badly if your first attempt is not accepted—it is just groundwork for attempt No. 2. As every experienced salesman knows, discouragement in selling a product or an idea is a luxury no one can afford.

A MOTOR IS A SERIES OF CIRCLES



All must be ACCURATELY CONCENTRIC if the motor is to run smoothly, quietly, trouble-free

CONCENTRICITY of Elliott C-W Motors begins with the bracket-to-frame fit, the reference for all subsequent "circles." Bearing bore and shaft bore are precisely centered within this accurate diameter.



TOLERANCE of 0.0007 in. for the bearing bore is checked by an air gage after finishing in a precision lathe. Master jig assures accurate positioning of bearing, essential to uniform air gap.

Elliott Crocker-Wheeler integral-hp a-c and d-c motors—from smallest to largest—are offered in all conventional enclosures and modifications; with insulation to suit the application, including EPA SEAL epoxy insulation, for use where conditions are most severe.

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GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

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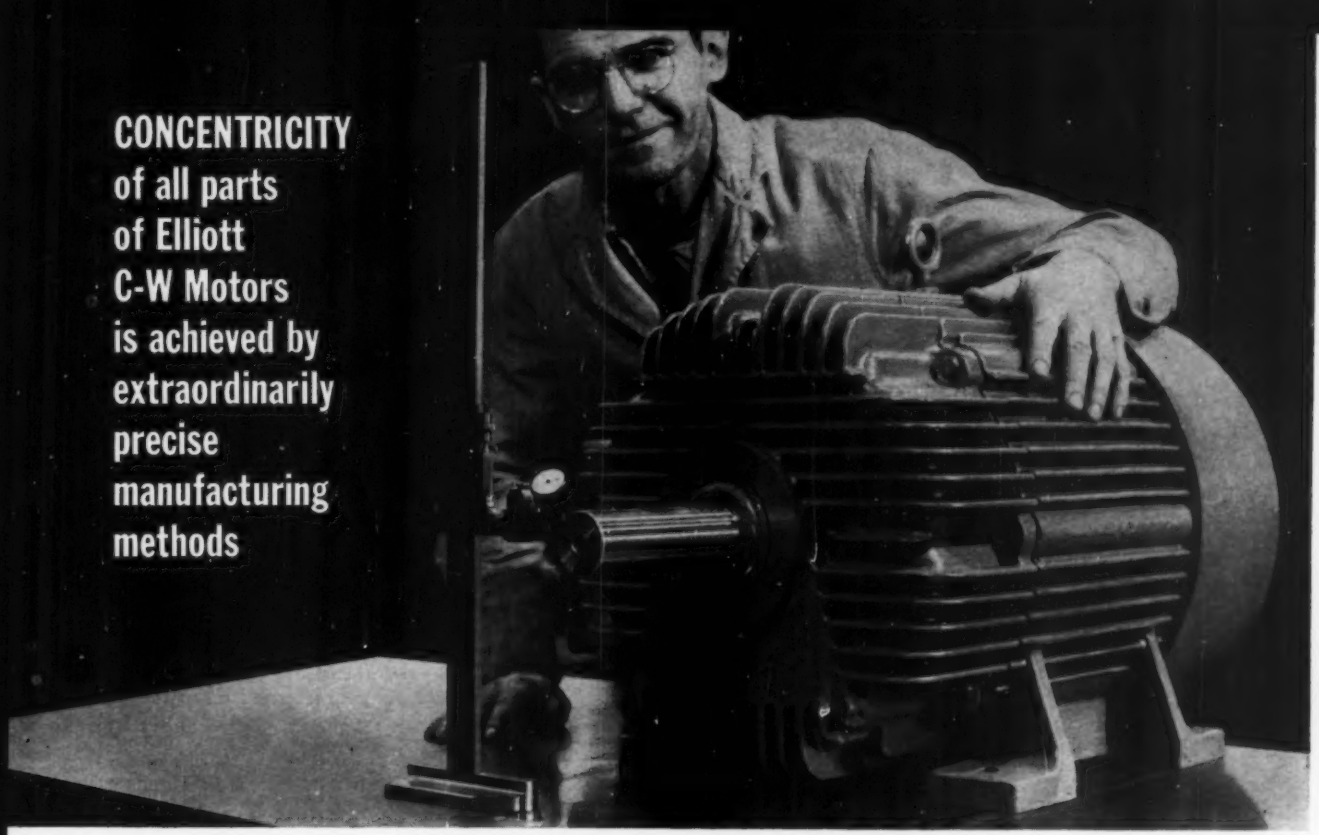
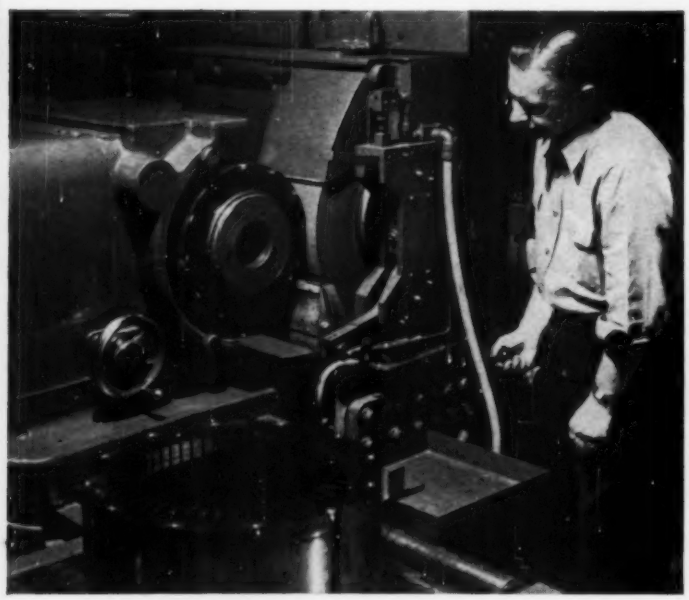
CIRCLE 26 ON READER SERVICE CARD

CONCENTRICITY of all parts of Elliott C-W Motors is achieved by extraordinarily precise manufacturing methods





PRECISION GRINDER finishes the outer surface of the stator core to a tolerance of 0.001 inches. It is then pressed and keyed into stator frame, which has been finish machined concentric with the basic bracket-to-frame fit.

DUPLICATING the basic bracket-to-frame fit, a jig accurately positions the wound stator for finishing the inside core diameter by a "fly cutter," which corrects for all accumulated tolerances and assures precise concentricity.

Key manufacturing operations employed in maintaining the required close tolerances are described more completely in an interesting brochure, *The Fine Art of Building Better Motors.* We will be very glad to send you a copy.

W1-2

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ELLIOTT COMPANY, Jeannette, Penna.
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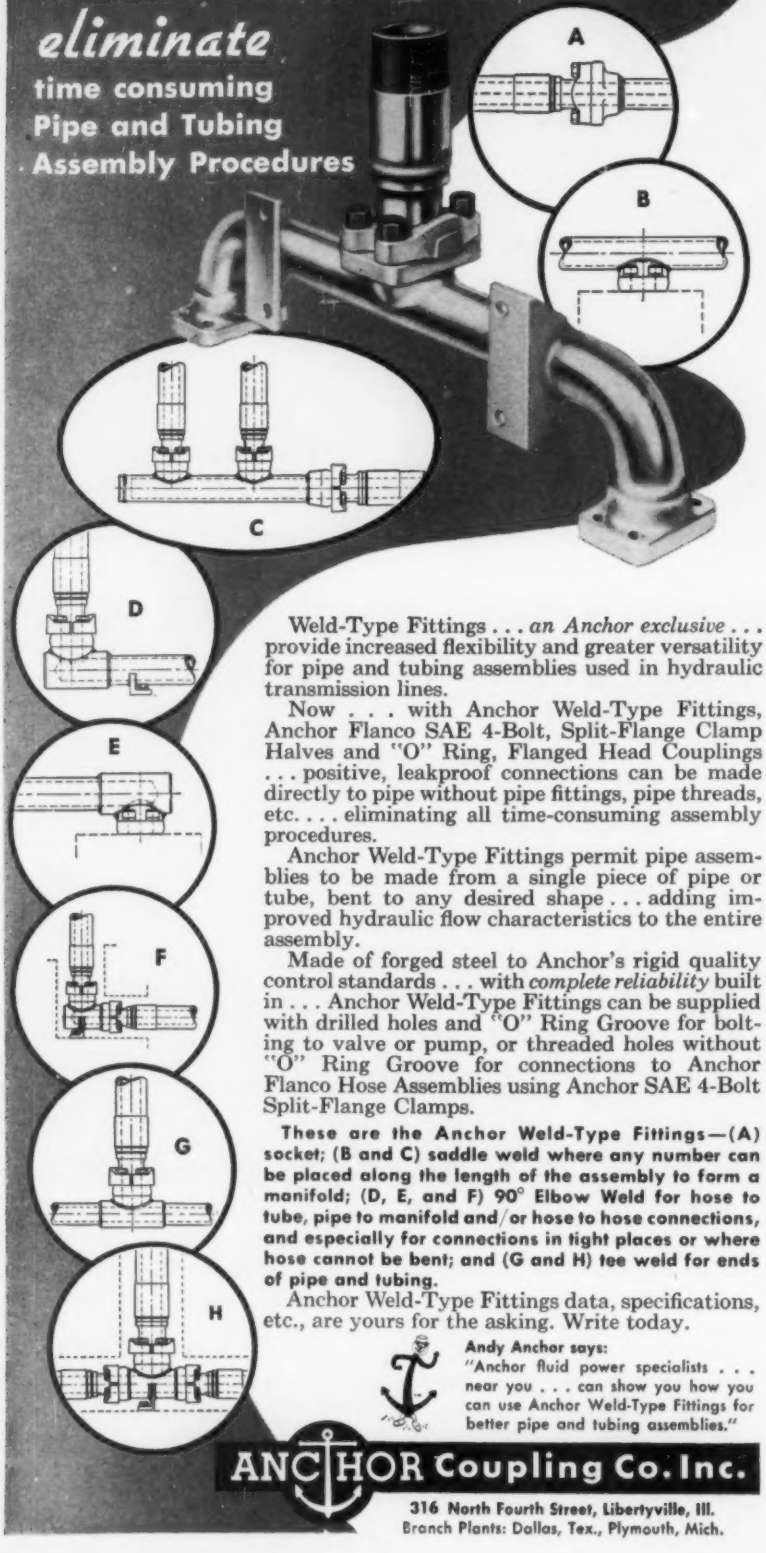

Weld-Type Fittings . . . *an Anchor exclusive* . . . provide increased flexibility and greater versatility for pipe and tubing assemblies used in hydraulic transmission lines.

Now . . . with Anchor Weld-Type Fittings, Anchor Flanco SAE 4-Bolt, Split-Flange Clamp Halves and "O" Ring, Flanged Head Couplings . . . positive, leakproof connections can be made directly to pipe without pipe fittings, pipe threads, etc. . . . eliminating all time-consuming assembly procedures.

Anchor Weld-Type Fittings permit pipe assemblies to be made from a single piece of pipe or tube, bent to any desired shape . . . adding improved hydraulic flow characteristics to the entire assembly.

Made of forged steel to Anchor's rigid quality control standards . . . with *complete reliability* built in . . . Anchor Weld-Type Fittings can be supplied with drilled holes and "O" Ring Groove for bolting to valve or pump, or threaded holes without "O" Ring Groove for connections to Anchor Flanco Hose Assemblies using Anchor SAE 4-Bolt Split-Flange Clamps.

These are the Anchor Weld-Type Fittings—(A) socket; (B and C) saddle weld where any number can be placed along the length of the assembly to form a manifold; (D, E, and F) 90° Elbow Weld for hose to tube, pipe to manifold and/or hose to hose connections, and especially for connections in tight places or where hose cannot be bent; and (G and H) tee weld for ends of pipe and tubing.

Anchor Weld-Type Fittings data, specifications, etc., are yours for the asking. Write today.

Andy Anchor says:
"Anchor fluid power specialists . . . near you . . . can show you how you can use Anchor Weld-Type Fittings for better pipe and tubing assemblies."

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READER TO EDITOR

Seat of Perception

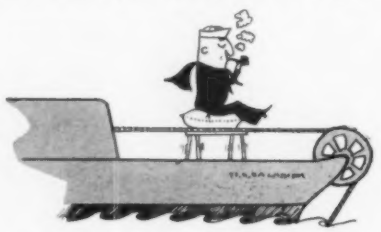
To the Editor:

Your recent editorial on "Industrial Baby-Sitter" (Mar 13) was most amusing and enlightening. Perhaps your loss of Dr Janet Travell's contribution of an article on seating has been a sacrifice on your part for the good of this country. With dangerous vibrations being generated by such countries as Congo, Laos, etc, Mr Kennedy could sure use a "sensitive seat." It is very comforting that Dr Travell knows the terriffic potential of sensitive gluteus maximus muscles and will assure us of a good seat in the White House.

F HARRY NEIDIG
Elna, NY

To the Editor:

I was entertained by your editorial re the true seat of perception. Some years ago, when in the employ of AT & T, I was engaged in trying to convert the art of ocean cable-laying to a science. It so happens that in spite of the most elaborate of tensiometers, when it becomes necessary to grapple for a cable on the ocean bottom, the following procedure is used: A cable is run from the cable engine, over a bow sheave, and up to several miles to the ocean floor. Then a rickety and decrepit table is placed beneath the cable line. A comfortable pillow is placed on the taut line, and one of the ship's contingent, skilled in the art, lights up his pipe and assumes the position. Hours or days later, while the ship steams slowly back and forth, and after sensing the passage of the grapnel



over every rock on the ocean floor, said crewman will calmly announce: "We've hooked 'er." I have always referred to this as the phenomenon of the precocious posterior. It was not until just a couple of weeks ago, while discussing muscle response times with Dr Edger Gasteiger, the neuro-physiologist, that I learned that he has great difficulty measuring the response time of well-developed muscles. They actually do respond faster than most instrumentation can follow.

—F W KINSMAN, PE
Fairport, NY

2-Cycle Engines—Here to Stay

To the Editor:

In reply to your article "Two-cycle Engines Going Out?" I would like to say "No." Go-Karts are a futile development and might disappear one day as fast as

continued on page 30

PAPER PEACOCK

Sweetest word
in the office heard
"that Ozalid paper's
a colorful bird."

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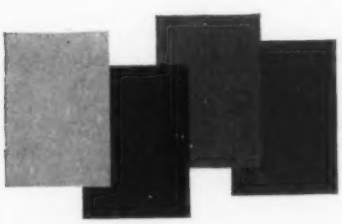

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• tolerances
• soundness
• intricacy

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they showed up; they cannot influence other applications. It is a pity that most US manufacturers of small 2-cycle engines still use the old inefficient way to scavenge cylinders with a deflecting nose on the piston. There are at least three well-developed scavenging systems used on most European-made 2-cycle engines. They render almost the same fuel economy as 4-cycle engines and offer simplicity and reliability.

The latest German development is a gas-injection system used on 2-cycle engines where only air is used for scavenging; these engines are really up-to-date regarding their performance and economy of operation. Of course nobody can stop some US manufacturers when they want to use 4 cycles, as long as the consumer public is willing to pay higher initial cost and is satisfied with them; but my opinion is that they are overlooking noteworthy developments in recent years in Europe on 2-cycle engines.

—Otto V Drtina
Chief engineer
Nylonge Corp
Cleveland

The Missing "n"

To the Editor:

Your pictures on p 20, Mar 6 issue, are headed by the title, "which photo is the Modrian?" Neither is—the painter of the picture at right was Piet Mondrian. In three mentions of the name, you left out the first "n"—each time a tribute to the consistency and conviction of your copy desk, but not to its culture.

—T E Jarnigan
Roslyn, NY

Which First, Profit or Safety?

To the Editor:

I am forced to write to you, for the first time, in an attempt to make a calm and reasoned reply to Brace Lewis, whose letter to you was on p 28 of your Mar 13 issue.

His point of view is one that has been a serious harm to American business whenever upheld. It is that the consumer's welfare comes second to profit. Think about that for a moment. To the extent that it does not shock you or your readers, thus is displayed our moral loss. One reason the capitalist system, the profit system, the private-enterprise system, has been under heavy attack in recent years is that many people are really convinced that under a for-profit system, the consumer's welfare is inevitably a byproduct, and an easily forgotten byproduct.

The American consumer is well educated and sophisticated (at least by the standards of his forefathers and most other nations) and if he ever gets really convinced that the profit system means his welfare will be neglected, he will demand—and get—a system without profits. Such opinions as Mr Lewis's cannot, must not, represent the official view of American business, and we must stamp it out wherever found.

I would like to point out that those

areas of endeavor which are given the greatest respect by all of us are those of the professions, where the codes of ethics specifically state that the governing motive must be the good of the client, not personal profit. Doctors, lawyers, professional engineers, and so on have found this point of such importance that a member violating it is universally condemned. It must be so condemned in the nonprofessional areas of life, too, or we will go the way of the dodo.

—RINEHART S. POTTS
Levittown, NJ

COMING EVENTS

APRIL

9-13 . . . . American Society of Mechanical Engineers, 33rd Annual Oil & Gas Power Conference and Exhibit, Jung Hotel, New Orleans

11-13 . . . . American Society of Lubrication Engineers, Annual Meeting and Exhibit, Bellevue-Stratford Hotel, Philadelphia

19-21 . . . . Institute of Radio Engineers, 13th Annual Southwestern IRE Conference and Electronics Show, Dallas Memorial Auditorium, Dallas

20-21 . . . . Society of the Plastics Industry, 18th Annual Western Section Conference, Hotel del Coronado, Coronado, Calif

23-25 . . . . American Society of Mechanical Engineers, Metals Engineering Conference, Penn Sheraton Hotel, Pittsburgh

MAY

7-11 . . . . American Society of Mechanical Engineers, Engineering Institute of Canada, Hydraulic Conference, Queen Elizabeth Hotel, Montreal

8-9 . . . . American Society of Mechanical Engineers, Lubrication Symposium, Hotel Deauville, Miami Beach

8-10 . . . . Institute of Radio Engineers, 13th Annual National Aerospace Electronics Conference, Biltmore & Miami Hotels, Dayton, Ohio

9-11 . . . . Western Joint Computer Conference, Ambassador Hotel, Los Angeles

9-11 . . . . Institute of Radio Engineers, 1961 Electronic Components Conference

10-12 . . . . Society for Experimental Stress Analysis, Spring Meeting, Benjamin Franklin Hotel, Philadelphia

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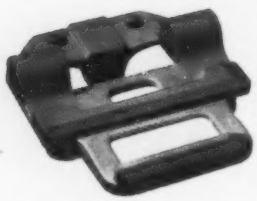

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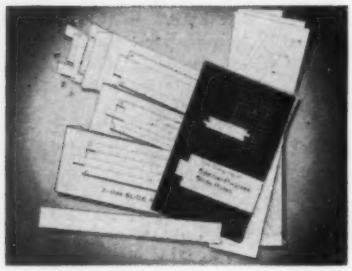


A design-it-yourself sliderule kit is being introduced by Dyna-Slide Co, complete with a 25-page manual telling how the job can be done. The kit (see photo) contains sliderule banks, a scale-plotting ruler, and a log chart. Price is $8.50, with refill blanks at $2.50 each.

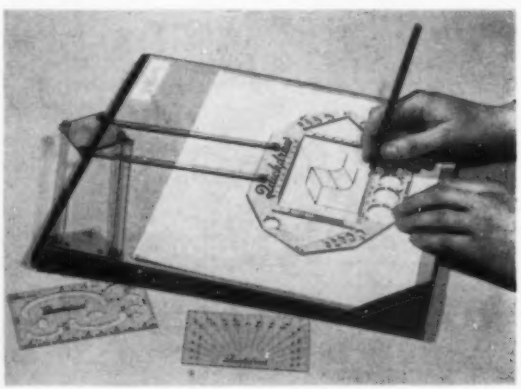
Quality control for typing

If your secretary wants to clean her typewriter keys, or remove typing errors without an eraser, Perry-Sherwood Corp, 255 Park Ave South, NY 10, has a solvent-detergent and an adhesive-like compound that may solve her problem.

The detergent is contained in a small vial in the center of a brush-like wick (see photo). Crush the vial, brush the type, and the detergent does the rest.

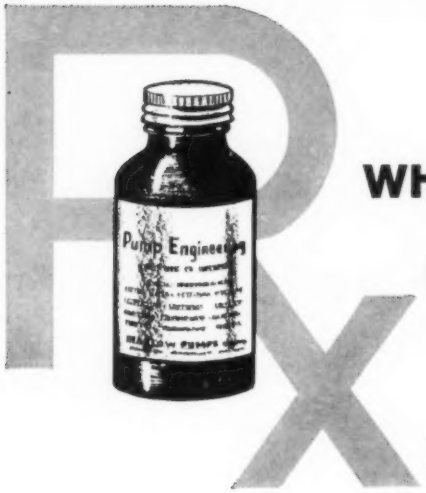
The "adhesive" is a tacky compound coated on paper and designed to pick up ink to "remove" errors as the secretary types over the copy. The cleaner, called *Britetype*, is priced at 98¢ for a box of 10 sticks. The *Perfectype* correction paper comes in a package of about 100 tabs (1 by 2¾ and 2 by 2¾ in.) for $1.98.

For a fast draw



Another new drafting aid — this one from England — is designed for engineers who want to work on the run. As the photo shows, it consists of a set of transparent templets which can be attached to the board by a toggle-hinged pantograph linkage, and can be used for everything from French curves to cross-hatching. Calibration is both in inches and millimeters. The board folds neatly into a carrying case; and the unit, complete with its case, weighs only 2 lb. The pantograph is removable, if desired, for mounting on a standard board. The Quickdraw Co, 127 Gunnersbury Ave, London W.3, makes it, has set an export price for the complete unit (with case) of $16.

(Note: For a new US drawing aid, see Feb 13, p 32.) —ARG



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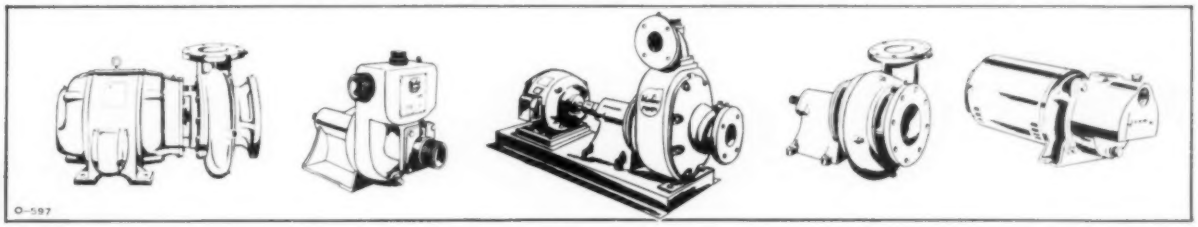
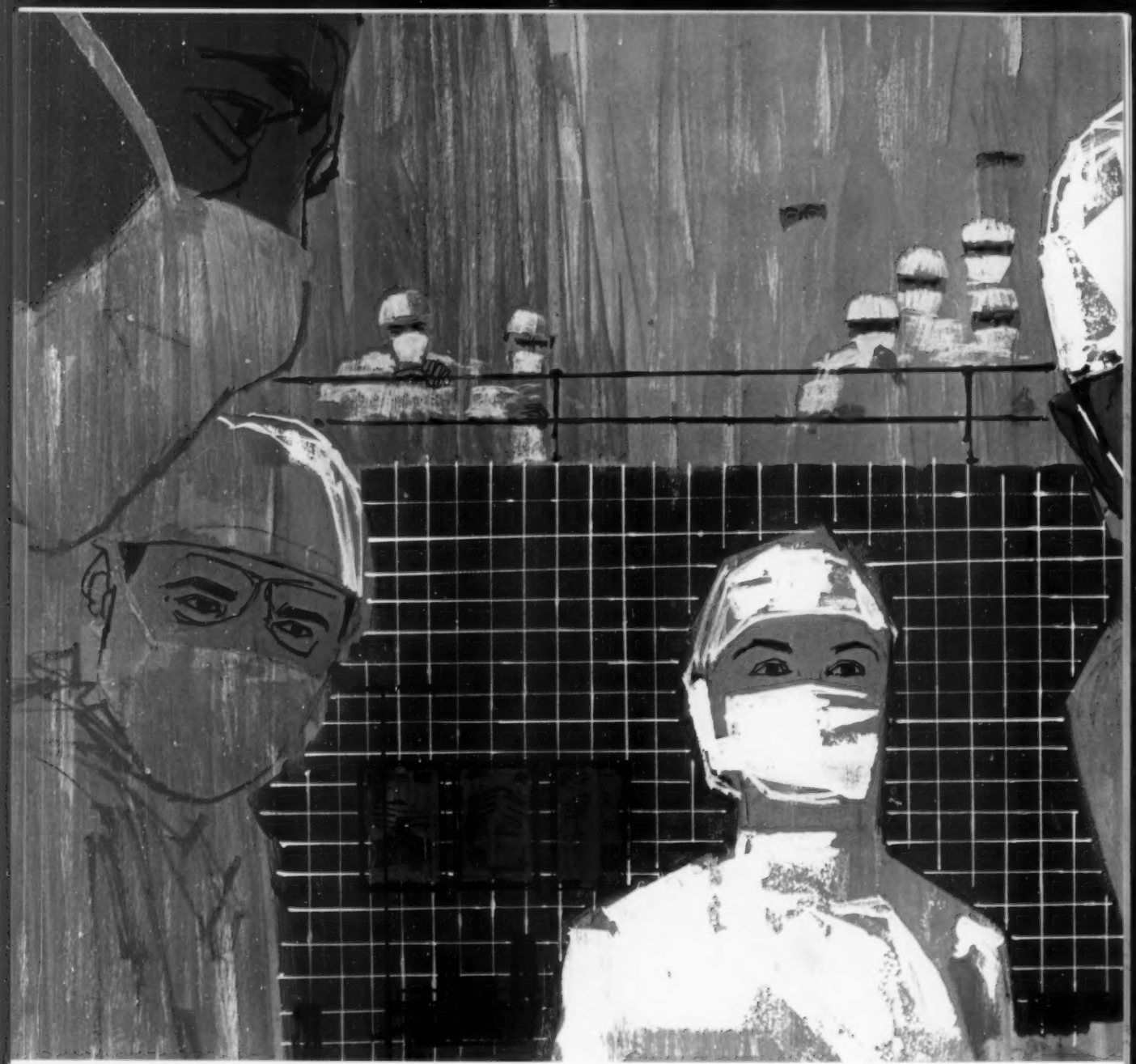


CIRCLE 33 ON READER SERVICE CARD

CIRCLE 34 ON READER SERVICE CARD



NS SPECIAL WIRE TRANSMITS

Doctors are saving more lives today in heart surgery cases through the transmission of carefully timed electrical pulses into the heart. Many patients suffering from lost heartbeat due to surgery or other causes have been restored to active life through such heart stimulation.

A LEADING MEDICAL INSTRUMENT COMPANY developed a pocket-size electronic package to generate the electrical impulse, which is transmitted to the heart through the jugular vein by a tiny stainless steel braided wire.

In their search for the right conductor to carry the electric pulses to the heart, researchers came to National-Standard for help in developing a wire flexible enough to follow the intricate path of the circulatory system, while, at the same time, soft enough to avoid damaging the blood vessels or the heart itself. In addition, the wire had to be very thin, strong enough to withstand the constant flexing of the heart, and with just the proper electrical characteristics.

NATIONAL-STANDARD ENGINEERS developed a braid of 16 wires, each .0036″ diameter, or about the thickness of human hair. Using type 302 stainless

SPARK OF LIFE

steel wire, NS engineers produced a braided wire with high tensile strength, good resistance to fracture, good conductivity and flexibility just right for the delicate application.

EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring high-quality wire, to meet special or unique applications, is available to you from National-Standard. Write for additional information to National-Standard Company, Niles, Michigan.

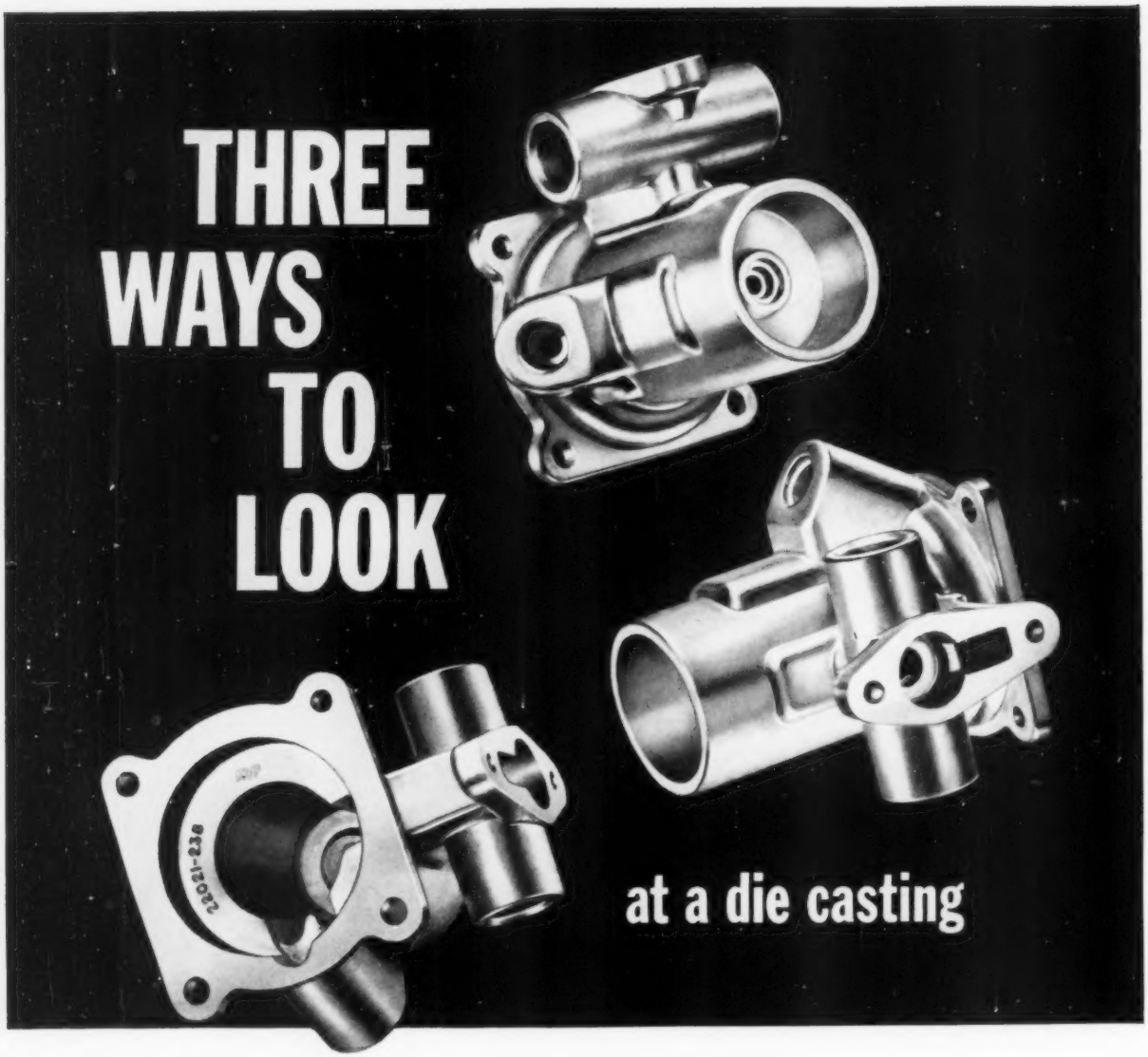
NS NATIONAL-STANDARD COMPANY

Manufacturer of Specialty Wire and Metal Products

NATIONAL-STANDARD COMPANY

Niles, Michigan

NS SPECIAL WIRE transmits spark of life from transistorized, battery-powered package, through jugular vein, to the heart. Carefully timed electrical pulses train tired hearts to beat normally again.



Madison-Kipp zinc and aluminum die castings

Here is a gas valve housing so intricate no one view could do it justice. Notice that the holes which are cast in reduce secondary operations. Cast in seats must be smooth and flat to prevent any danger of leakage. Dimensions must be held to close tolerances.

There are three ways to look at a die casting. First, the engineering that goes into the design and the skilled die making that assures perfect castings. Second, the experience of the die caster that guarantees quality parts in quantity. Third, his reliability and responsibility backed by years of die casting experience.

On all three counts—engineering, production, responsibility—Madison-Kipp has won the confidence of manufacturers who demand the finest.

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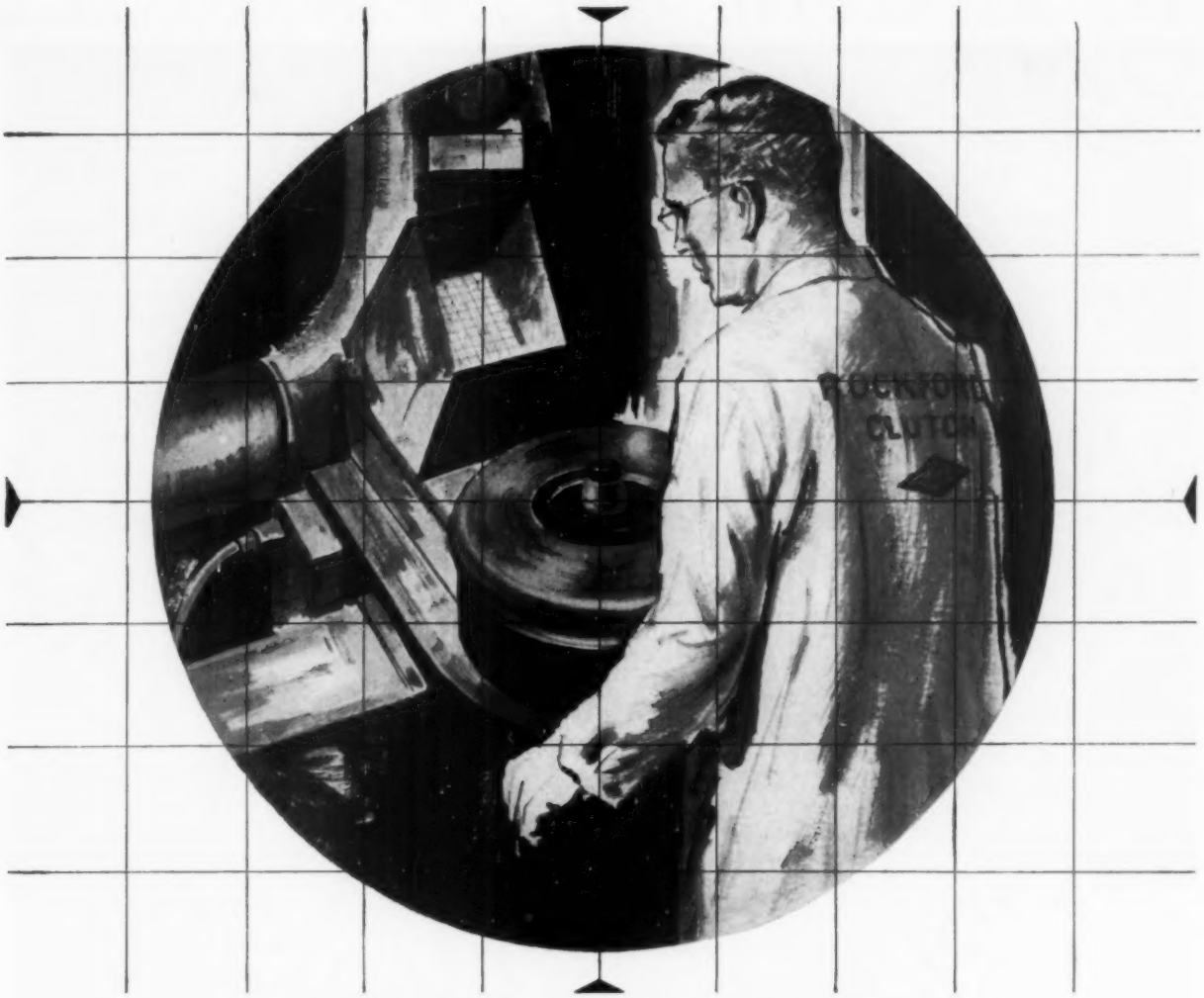

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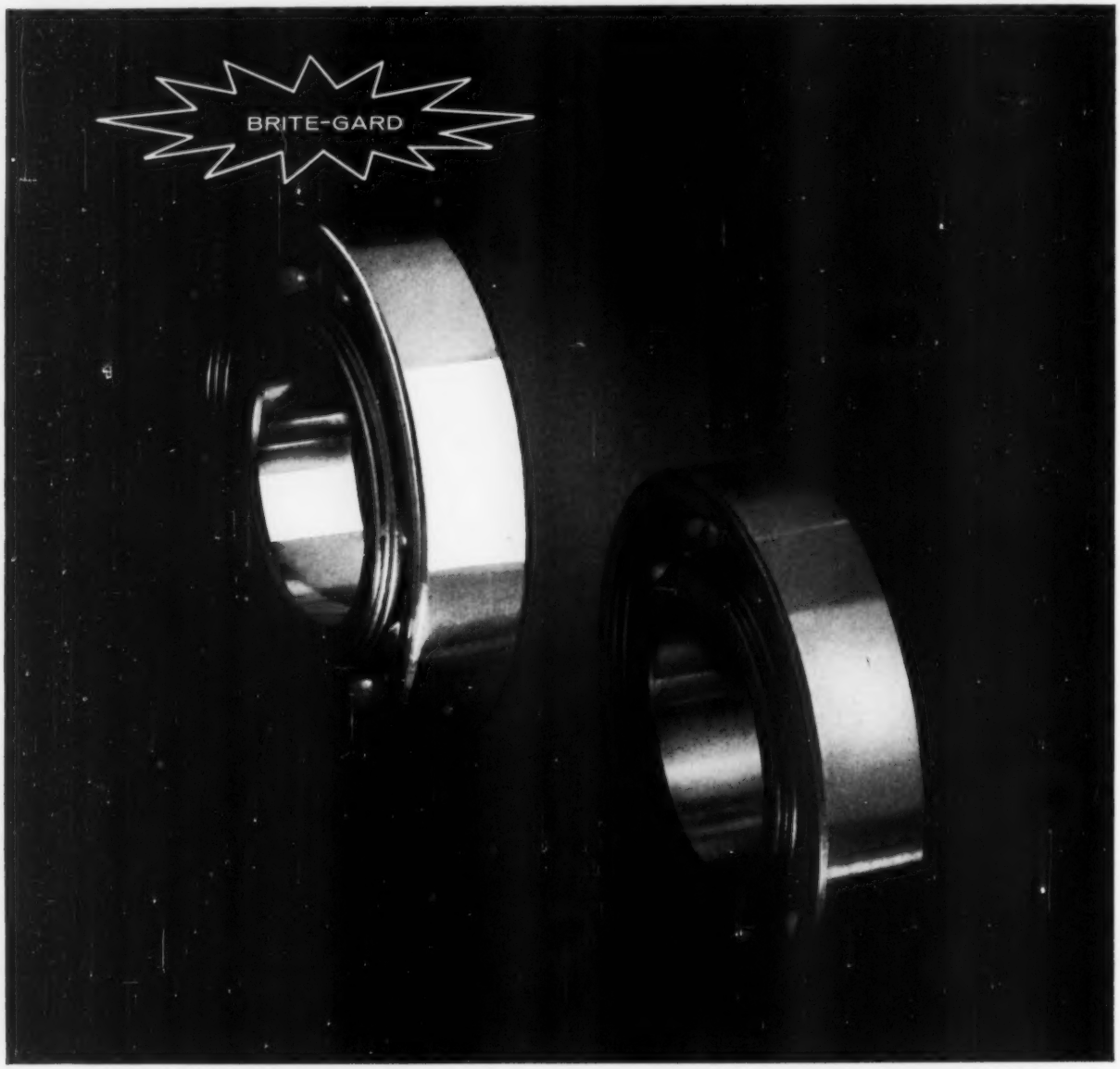

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PRODUCT ENGINEERING HORIZONS

April 10, 1961

A Solomon for Security?

A real secret, some wag has said, is information shared between *one* people. Every thoughtful person knows that the likelihood of maintaining secrecy declines in geometric ratio to the number of people involved. Yet we Americans have "national secrets," elaborate classification systems and security clearances, and the curious and archaic institution known as "company secrets." Europeans, whom we have always regarded as the masters of cloak-and-dagger diplomacy, are inclined to bow to us as the originators of several added fillips; engineers there have been finding that their interchange of information is being curtailed by extension of our military and proprietary "secrecy" concepts through NATO and international companies (*PE*—Aug 29 '60).

Actually, no two Americans, "experts" or laymen, agree on what security is, as all editors know. The result is chaos, with foolish restraint as one extreme and over-publicity as the other. We Americans talked too much before Sputnik I about what we expected to do, too little about the difficulties inherent in any pioneering and test program. We vacillate between over-generosity and over-parsimoniousness on information as we do on funds.

At the national level, classification is too often at the whim of regimentation or politics—often to hide embarrassing mistakes. There, as at company level, the result is simply to keep needed information from customers and friends—the enemy or competitor has already made sure of the steps necessary to obtain it.

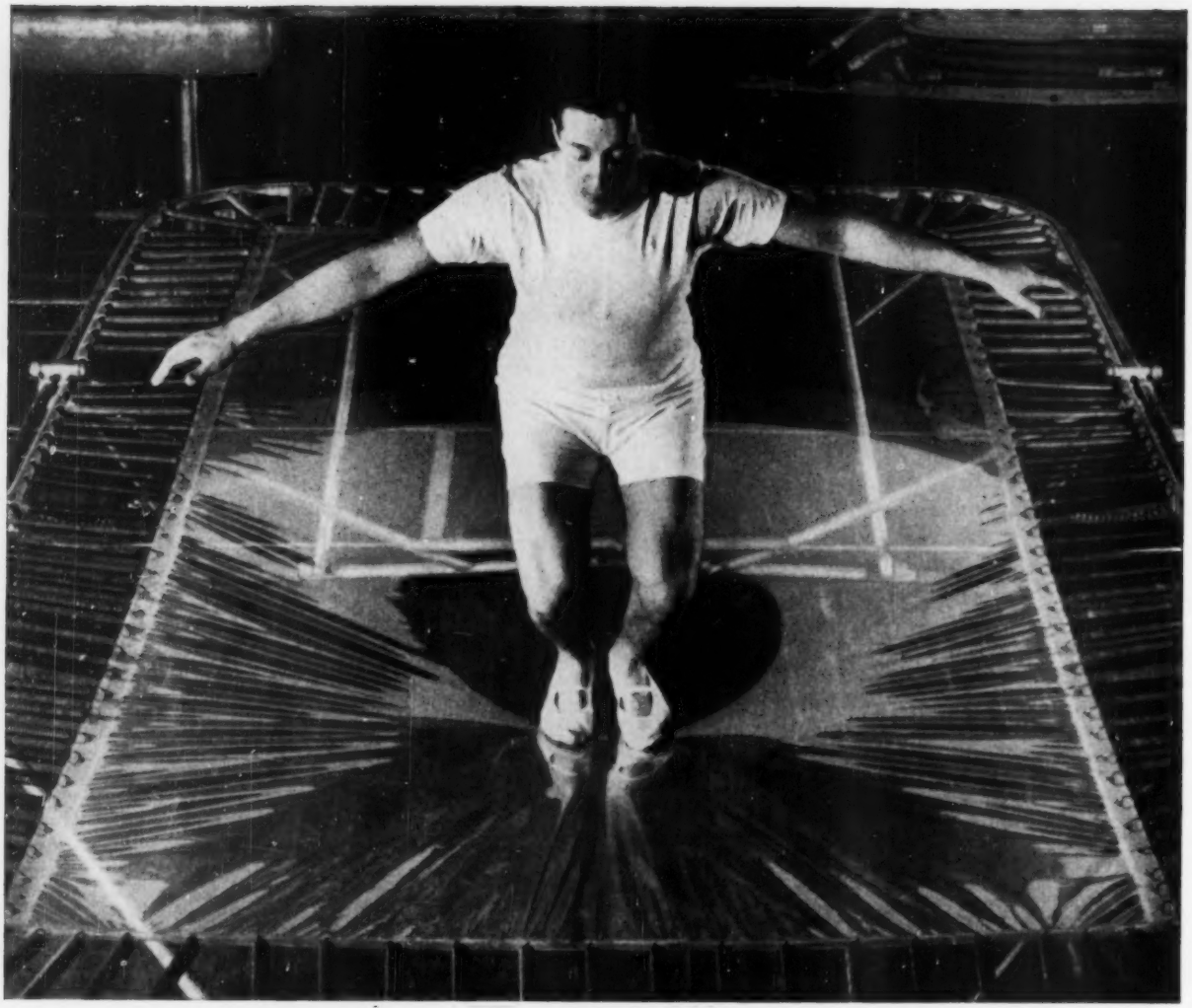
We have just been through such a comedy of errors in the sale—then cancellation—of a million dollars worth of miniature-bearing grinders to the USSR. It is now generally agreed that the sale was foolish in the first place. Our machines would undoubtedly have been made prototypes for Russian designs, just as countless others of our designs have been—in automobiles, machine tools, other machinery, processes and methods. But to leap to the conclusion that cancelling the sale will keep the knowledge from the Russians is foolhardy—the builder had already sent operator's manuals to the USSR in accordance with the approved contract provisions, so the basic ideas are revealed anyway.

In this particular instance, our machines are far more advanced, so any delay is worthwhile, but it is likely to be quoted as a precedent in stopping export of an endless number of devices, just as "military importance" has become the excuse for keeping *all* information from the public, strategic or otherwise.

This is where the chaos starts. One interpreter of security can rule that everything is classified, another that almost nothing is—and both can defend their positions. One government official can insist our designs are so vital that we can't publish anything on new research results, another can be so conscious of the gold outflow that he'll be willing to sell strategic production machinery to our potential enemies.

We need an individual in government who can lay down an understandable policy, and an electorate and staff who are willing to accept that policy without niggling and nit-picking. Any release of information is a calculated risk; we need somebody in government—and in industry—who can appraise the risk and rule accordingly.

Is there a Solomon in the house?



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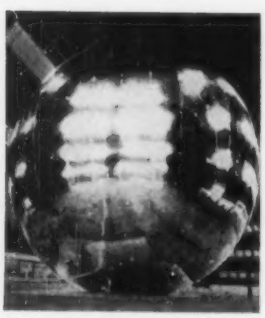

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PRODUCT ENGINEERING

special report

HOW TO CHOOSE THE RIGHT ELECTRICAL INSULATION

Equipment manufacturers now offer a wide range of materials. Which one to choose? Here's a simple method, based on two comprehensive tables, that helps find the best one for your application.

A J SHERBURNE, *systems specialist, Insulation Materials Dept, General Electric Co, Schenectady*

When you buy a motor, control or other electrical component today, the manufacturer can give you an extremely wide choice among electrical insulating materials. Many of them are completely new, with made-to-order properties. The problem is how to choose the best type from such a vast selection.

It's not hard to find an insulation with the right theoretical electrical properties; the trick is to make sure it will retain them during manufacture and on the job. For example, during its application to the equipment, the insulation is pressed, twisted, pounded, scraped or heated. And after it is in place, it's subject to aging and unavoidable abuse.

To make sure you find the right insulation and take full advantage of its properties you must consult an expert—usually the equipment or materials manufacturer. But before you call him in you can save time by eliminating the unsuitable materials and concentrating on the ones that will work. Here's a systematic way to go about this weeding-out process.

Four steps to the right choice

First—examine the requirements: ambient temperature, heat generation, overloads, dirt, dust, fumes, moisture, vibration, mechanical protection, maximum and average electrical potential, ease of maintenance, ease of testing, desired life, thermal conductivity needed, weight, size, cost, safety factor, and fire resistance. Arrange the list in order of importance for your particular application.

Second—anticipate the manufacturer's problems in assembling an insulation system—several operations may be involved, such as wedging, inserting ground insulation, coating, and encapsulating. Each function may require a different insulating material or compound.

Third—locate likely materials in the Properties table (p 44). For specific details on any given material, consult manufacturers' literature or published references such as *The Insulation of Electrical Equipment*, by W. Jackson (John Wiley and Sons Inc), and *Electrical Engineers' Handbook* (McGraw-Hill Book Co).

Fourth, and most important—consult manufacturers prepared to supply components with the insulation materials or systems you have selected. Only a specialist can advise you on limitations in any of the materials chosen. Your own factory tests then can help screen the final selections and achieve the best compromise.

continued, next page

REPRINTED—Circle 599, inside back cover

HOW TO USE THE TABLES

The four-page table "Properties of Insulation" starting on p 44 and the "Applications" list on p 50 summarize important information on commercially available insulations. About three dozen key properties for six dozen different materials were selected from over 120 properties and hundreds of materials on which test data were available. The missing ones are variations of those given, or are not important in the choice of a practical insulation system.

The table of properties has comparative values only: E for excellent, S for satisfactory, and U for unsatisfactory. It is impractical to tabulate quantitative values because of the wide varieties of composition and construction possible. A blank space signifies non-applicability to the particular material, or in some instances, lack of information. For instance, punchability is not important for magnet wire, and crease-resistance of a potting resin is meaningless.

The list of mechanical properties at left end of table has two entries on each line—just choose the term that applies. For instance, good low-temperature flexibility applies to solids, fluidity to dielectric oils.

Treated and untreated materials are listed together, with a single value for both. However, the range of properties of treated insulation can be estimated by noting the limiting values for each of the constituents —varnish and cloth for example. Special limitations are discussed in the text, under materials (p 48).

Not included in the performance table are special properties and characteristics specific to each type or grade of material: appearance, color, form, commercial sizes, thickness, weave, density, solvents, proportions of composites, and actual values of dielectric strength. These vary greatly even among similar materials, but you can usually find suitable values in commercial catalogs for any material you choose.

The list of applications gives standard types of equipment using electrical insulation, showing which materials are most frequently chosen to do the job. Most insulation systems need more than one material.

There will be many exceptions to the table because specific requirements of the application—voltage, speed, size, frequency, temperature, duty cycle—will strongly influence the choice of insulation. The table assumes typical conditions. For special conditions, refer to the Properties table.

KEY PROPERTIES OF INSULATION

Thermal endurance

Temperature stability is the most important factor in the life of insulation, so all insulation standards for industrial electrical equipment are based on the temperature classifications on facing page. Classes F and H have been recently created to keep pace with silicones and other high-temperature insulating materials.

In AIEE (American Institute of Electrical Engineers) Standard No. 1, an insulation system is rated on temperature performance. The old standards arbitrarily limited certain materials to a given class. With no limitation other than meeting performance requirements, insulation now can be designed to exactly match the need, with savings in cost and size. Some existing insulation systems can be allowed to run hotter, increasing usable overload margin of the equipment.

Accelerated thermal-life tests at higher temperatures help determine if an insulation qualifies for a given temperature. As temperature is raised, any organic insulation (most insulations are organic) will deteriorate faster. A rule of thumb: each 10-deg C (18-deg F) rise halves life. However, the useful limit has been raised from 105 C by modern organic chemistry, and some materials can operate at 180 to 220 C (360 to 430 F) and possibly higher for the life of the equipment.

Another thermal property—heat conduction—is important too. If heat generated in the electrical conductor is dissipated rapidly through the insulation, more load can be carried without deteriorating the insulation or causing burnouts.

Electrical properties

Electrical properties are basic to any electrical insulation. Thermal, mechanical, chemical properties merely help the insulation do its electrical job.

Dielectrics are insulators that can withstand an electrical stress—high potential between conductor and ground. Good electrical insulators are not necessarily good dielectrics; resistance to current flow (insulation resistance) may be high but the material might break down (lose resistance) at relatively low potential.

Dielectric strength, v/mil (1 mil is equal to 0.001 in.), is a measure of insulation breakdown potential. Most good dielectric materials range from 500 to 2500 v/mil in thin section, but value decreases with thickness. Increases in operating temperature, adsorption or absorption of moisture, accelerated aging and other conditions will reduce dielectric strength of the insulation. Sudden surges of potential during switching or from an electrical storm may be enough to damage the dielectric. A large safety margin must be used.

Motor and generator insulation is normally made thick enough to limit potential gradient to a conservative 20 to 50 v/mil, insuring reliability even with adverse environment, physical abuse during assembly and difficult operating cycles.

Capacitors, transformers, and similar nonrotating equipment can be protected mechanically more easily than motors, and require much less electrical design margin. Voltage gradient can be as high as 500 v/mil.

Electronic devices and circuits also have insulation with voltage gradients up to 500 v/mil. But exceptionally good dielectric properties are needed because the devices are relatively small and operate over wide ranges of temperature, potential and frequency; and electrical safety margin is small. Deterioration agents such as oxygen, air, moisture and chemicals must be excluded—usually by encapsulation or hermetic sealing.

Voltage endurance is a measure of how long an insulation system can withstand a given potential and maintain its dielectric strength. Humidity and voltage-cycling have a very great effect on life.

INSULATION TEMPERATURE CLASSIFICATIONS (FROM AIEE)

Class	Max Temperature °C	°F	Examples (Insulation must be proved suitable for rated temperature)
O	90	194	Untreated cellulosics (paper, cotton) not immersed in oil
A	105	221	Organic insulation such as Formvar, paper, cotton
E	120	248	(European classification; not used here)
B	130	266	Epoxy varnish, Dacron-glass serving, rubber
F	155	311	Polyester (Mylar), urethane
H	180	356	Asbestos cloth, glass cloth, Teflon, silicone rubber
C	220+	428+	Inorganic insulation: ceramics, glass

Insulating efficiency is a measure of how little power is lost in heat or electrical leakage compared with power transmitted by the conductor. The two important losses are dielectric loss and leakage current.

Dielectric loss in insulation is electrical energy expended by the electric field and dissipated by heat because the insulation is not a perfect dielectric. It can be measured as power factor, dielectric constant, and Q-factor. A low-loss material such as polyethylene is recommended for high-frequency electronics and similar applications, although it softens at temperatures above 75 C (about 165 F) and has poor resistance to abrasion and cold flow.

Power factor is the ratio of power lost through the insulation in phase with the applied voltage, to the total power in the conductor. This ratio is approximately watts lost as heat divided by v-amp input. Dielectric loss usually increases with voltage, temperature and frequency—commercial dielectric heaters exploit this fact by operating in the megacycle range at potentials from 1500 to 5000 v/in.

Dielectric constant—a characteristic of the material—affects dielectric losses. It is the ratio of the electrical energy that can be stored in a capacitor (or an insulation system) using a dielectric of the given material, to that stored in a geometrically identical capacitor with air as the dielectric. Its value should be high for high frequencies (thousands to millions of cps) where the continuous rapid reversal of the electric field may heat up the dielectric and shorten its life—or even end it abruptly if "runaway" results.

Q-factor is approximately the reciprocal of power factor, and is a more direct way to express insulation efficiency: efficiency is proportional to Q. If power factor is 0.001, then Q-factor is approximately 1000. Rigorously defined, Q-factor for a coil is the ratio of coil reactance to effective coil resistance.

Leakage current, measured by surface or volume resistivity, is conduction through or around the insulation. Low insulation resistance and presence of voids, moisture and short-circuit paths will increase leakage

Electrical arcing can create very high temperatures which may burn and carbonize the adjacent insulation. Materials vary widely in resistance to arcing damage.

Corona—the visible discharge of electricity around a conductor when potentials are high—can destroy insulation by electron impingement from the ionized air. Ozone and other gases are formed, hastening the deterioration. Surge potentials during switching can also cause arcing or corona. An actual test is shown on the cover.

Insulation systems can be designed to reduce the likelihood of corona—the trick is to keep the voltage gradient as low as possible. Thick and homogeneous insulation, absence of voids, high-density material, careful manufacturing technique, and balanced mechanical configuration are important. Where operating voltages must be above "corona-starting voltages," choose mica; it can operate in corona without damage.

Electrical measurements

Measurements of dielectric strength are useful mainly as quality checks on manufactured insulation or assembled equipment; voltage endurance tests upon actual operating structures are more informative for quantitative evaluations such as prototype and acceptance tests. Test measurements of power factor and Q-factor help evaluate high-frequency performance, and detect voids, puffed insulation, trapped moisture or solvents, and variations in density of wound or compounded insulation. Tests for arc resistance are important in high-current, high-potential switchgear applications; considerable scientific work is being done on "tracking" and dielectric breakdown. Tracking is a surface phenomenon wherein high potential or high currents applied across a sheet or strip may generate a conducting path along the surface depending on the material, atmosphere and other conditions.

Mechanical requirements

Insulation has to be applied—a mechanical problem—and must also withstand mechanical abuse from then

text continued, page 48

Code: E — Excellent, S — Satisfactory, U — Unsatisfactory	Coatings on Magnet Wire (for motor windings and controls)													Liquid Resins (converted to solid by heat or catalyst)		
	ENAMEL									SERVING (WRAPPING)						
	Oleoresin	Formvar	Epoxy	Polyester	Nylon	Acrylic	Polyurethane	Butvar	Teflon	Cotton	Glass	Asbestos	Dacron-glass	Polyester	Epoxy	Urethane
Thermal																
Temperature class	A	A+	B	F	A	A+	A	A	H	O-A	B,F,H	B-H	B	B,F	B,F	B,F
Heat dissipation																
Low aging loss: weight														S	E	E
properties (elec.)				E										E	S	E
Heat shock	U	E	E	S	E	E	S	E	E							
Electrical																
Dielectric strength	S	E	E	E	E	E	E	E	E	S	S	S	S	S	E	E
Voltage endurance									U							
Insulation efficiency: low dielectric loss	U				U		E			U	U	U	U	U-S	U-S	S
high Q (1/power factor)							E			U	U	U	U	U		
high insulation resistance		S	E							U	S	U	S	E	E	E
Can withstand: arcing											S	U		E	E	E
corona							E							S	S	S
Mechanical																
Bond strength; adhesion	U	E	S	E	E	S	S	E	U	S	S	S	S	U-E	E	E
Flexible; can be wound	S	E	S	S	E	S	S	S	U			S	S	U-E	U-S	U-E
Flexible (or fluid) at low temp.														U	S	E
Good elongation, stretch	U								U							
Abrasion; hardness	U									E		S	S	S	S	E
Tough; tear-resistant		E		E	E							S	E	S	S	E
Cut and crush-resistant	U			E					U			S				
Crease-resistant																
Can be formed, molded																
Can be punched																
Break strength, tensile																
Impact, resilience, flexure												S				
Low plastic flow with temp.	U								E							
Low shrink.; dimens. stable														S	E	E
No voids, porosity, defects																
Non-swelling														E	E	E
Chemical																
Compatible with: solvents	U	E	S		E		E	U	E					S	E	E
oils		E	E	E		E								S	S	E
refrigerants	U	S		E		E				S	S			E	E	
humidity, moisture	U	E	E	S	U	U	E			U	S	U	S	S-E	E	E
water (immersion)	U	S	S							U	S	U	S	S	E	E
chemicals		E					E		E	U	S	S	S	E	E	E
Fire-resistant	U	U									S	E				
Doesn't handicap soldering					E		E									
Cost, relative within group: lowest = 1	1	2			9					1	3	2	4	1	2	3

	Varnishes (mostly thermosetting resins, with drying oils or solvents)								Filled Resins and Varnishes (includes pigmented types)						Papers (coated and uncoated)						Films			
											COMPOUNDS:			ELASTOMERS:										
	Asphalt	Phenolic	Modified phenolic	Epoxy	Alkyd	Polyester	Silicone	Acrylic	Paint (insul.) Putty		Filling	Treating	Encapsulating	Rubber	Silicone	Kraft	Rope	Pressboard	Vulcan-fiber	Asbestos	Mica paper	Teflon	Cellulosic	Polyethylene	Polyester (Mylar)
	A,B	A	A,B	B	B,F	F	H	A	A,B,F		A-H	A,B	B,F	B	F,H	A	A	A	A	B,F	B,F,H	H	A	A	A+
														E	E	U	U	U	U	U	U	U	U	S	U
	U	U	S	S	E	E	E	S	S	S	S	S	E	S	E	U	U	U	U	S	E	E	U	S	E
	U	U	S	E	E	E	E	E					U-E												
	S	S	E	E	E	S	S	S		S			S	S	S	S-E	S-E	S	S	S	E	E	S	S	E
						S	S							S	E	S	S	S	S	U	E	U	E	S	U
	U	U	U	S	U	U	S						U-E	S	E	U-E	U-E	S	S-E	U	E	S	S	E	S
													U-E			S-E	S-E			U	S-E	U	U	E	S
	S	U	S	S	E	E	S		S	S		S	S	S	E	S	S	S	S	S	S	E	E	E	E
	S	U	S	S	E	E	E		E	S		S	S	E	S			S	E	U	E			E	
						S	S					S	S	S	E	U	U	U	U	U	E	U		U	S
	S	S-E	S-E	E	U-E	S-E	U-S	S-E	S-E	S-E	S	S	E	S	S							U	S	S	S
	S-E	U	S	S	S-E	S-E	S-E		S													E	E	E	S
	U	U	U	S	U	U	E		S													S		S	U
									E	S	S	S	S	S	E							S	E	S	E
	S	E	E	E	U-S	S-E	U	S																	
	U	U	E	E	U	E	U	S						S	U-S	U	U	S	E	S	U	U	S	E	E
	S	E	S	E	S	S	U	S						U-S	U-S	S	S	E	E	S	S	U	S	U	S
																E	S	S	E	U	U		S	E	E
														E	E										
																E	E	E	S	S	S	S			
														U-S	U-S	S	S	S	E	S	S		S	U	E
									S				S	U-S									S	S	E
	U	E	S	E	U	S	S				S		S-E	U-S	S	E	E	E	E	E	S	S	S	U	S
													S	S	S	U	U	U	U	U	E	S	U	S	U-S
																U	U						S	S	S
	S	E	E	E	S	S	U	E	E				E	U-S	U-S	E	E	E	E	E	E	E	E	S	E
	U	S	E	E	E	E	U	E	E				E	S	S	E	E	E	E	E	E	E	E	U	E
	U	S	U	S	U	S	S	E								E	E	E	E	E	E	E		U	E
	E	S	S	E	S	S	E	S	E	S	E	E	E	S	E	U-S	U-S	U-S	U	U	E	E	U	E	S
	E	U	E	E	S	S	E	S				E	E	S	E	U	U	U	U	U	S	E	U	E	S
	E	E	E	E	S	S	E	E	S		E	E	E	S	E	U-S					E	E	E	S	S
									U		U-S	U-S	U-S												

table continued, next page

Code: E — Excellent S — Satisfactory U — Unsatisfactory	Plastic Tape (and sleeving, tubing, sheet)					Textiles (woven, nonwoven; varnished, unvarnished)							
											SILICONE ON:		
	Vinyl	Polyethylene	Polyvinyl chloride	Irrathene	Silicone rubber	Cotton	Glass	Dacron	Dacron-glass	Asbestos	Glass	Dacron-glass	
Thermal													
Temperature class	A	A	A	A	H	A	B,H	A,B	B+	B,H	H	F	
Heat dissipation	U	S	U	S	U	U	U	U	U	U	E	E	
Low aging loss: weight													
properties (elec.)	U	U	U	S	E	U	S-E	S	S-E	S-E	E	E	
Heat shock											E	E	
Electrical													
Dielectric strength	S	E	E	E	E	E	E	E	E	S	S	S	
Voltage endurance	U	S	U	S	E	U	S	U	U	U	E	E	
Insulation efficiency: low dielectric loss	U	E	U	E	E	U	S	S	S	U	E	S	
high Q (1/power factor)	U	E	U	E	S	U	U	U	U	U	S	S	
high insulation resistance	S	E	E	E	E	S	S	E	S	U	E	E	
Can withstand: arcing		E	U	E							S	S	
corona		E	S	E		U	S	S	S	S	E	E	
Mechanical													
Bond strength; adhesion		S		S	U-S						S	S	
Flexible; can be wound	E	E	S	E	E						E	E	
Flexible (or fluid) at low temp.	U	S	U	S	E						E	E	
Good elongation, stretch	S	S	E	S	S						E	E	
Abrasion; hardness													
Tough; tear-resistant	S	E	S	E	S	S	E	E	E	S	E	E	
Cut and crush-resistant	S	U	U	U	U	S	S	S	S	S	S	S	
Crease-resistant	E	E	E	E	E	S	U	S	S	U			
Can be formed, molded											S	S	
Can be punched													
Break strength, tensile	S	U	S	U	S						E	E	
Impact resilience, flexure	S	S	E	S	S								
Low plastic flow with temp.	U	U	U	E	S						S	S	
Low shrink.; dimens. stable	U	S	U-S	S	E						E	E	
No voids, porosity, defects	S	S	S	S	S								
Non-swelling													
Chemical													
Compatible with: solvents	U-S	S	U-E	S	U	S	S	S	S	S	S	S	
oils	U	U	U-E	U-S	U-S	S	E	E	E	E	S	S	
refrigerants	U	U	U	U	U	S	S	S-E	S-E	U			
humidity, moisture	S	E	S	E	E	U-S	S	S	S-E	U-S	E	E	
water (immersion)	S	E	S	E	E	U	S	S	S	U	E	E	
chemicals	U	S	U	S	S	U				U-S	E	E	
Fire-resistant												E	
Doesn't handicap soldering													
Cost, relative within group: lowest = 1													

	Flexible Laminates (tapes, composites)								Rigid Laminates (sheets, tubes, rods with silicone, phenolic, polyester, melamine)					Molded Plastics		Ceramics and Inorganics					Oils		
	PAPER:		ASBESTOS		MICA PAPER		MICA FLAKES																
	With film	With film and varnished cloth	With film	With glass cloth	With film	With glass cloth	With paper or film	With glass and film	Polyester film	Paper	Cotton	Asbestos	Glass	Mica mat	Thermoplastic	Thermosetting	Porcelain	Steatite	Alumina	Mica block	Glass	Mineral	Askarel	Silicone
	A	A+	A,B	B,H	B,F,H		B,F	B,F,H	A,B	A	A	B	B,F,H	B,F,H			C	C	C	C	C	A	A	H
									S	U		U	U	U	U-S	U-S						E	E	E
	U	S	S	S	E	E	E	E	S	S	S	S	E	E								S	E	E
	S	S	S	S	E	E	E	E	E	S	E	S	S-E	E	S	S	S	S	E	E	S	E	E	E
	U	U	U	U	E	E	E	E	U	U-S	U-S	U	S	E	U-S	U-S	S	E	E	E	S			
	E	U	U	U	E	S	E	S	U	U-S	S	U	S-E	E	U-E	U-E	S	E	E	E	S	E	E	E
	E				E					U-S	S	U	S	E	U-E		S	E	E	E				
					S	S	S	S	S	U-S	U-S	S	S	E	U-E	U-E	S	S	S	E	S	S	E	S
					S	S	S	S	U	U	U	S	U-E	E	U-E	U-E	S	S	S	E	S	S	E	S
					E	E	E	E	U	U	U	S	S	E	U-E		S	E	E	E		E	E	
	E	S	E	S	S	E	S	E	S								U	U	U	U	U			
	S	S	S	S	E	S	E	S	E						S		U	U	U	U	U			
	U	U	U	U	U	U	U	U	U						S		U	U	U	U	U	S	S	E
			S	S	U	U	U	U	S								U	U	U	U	U			
	S	S	S	S	S	S	S	S	S				E			E	E	E	E	E	S			
	S-E	S	S-E	S	E	S-E	E	E	E	U	U	S	S-E	S-E							U			
	S		E	E	S	S	E	E	S	E	E	E	E	S-E							U			
	S	S	S	S	U-S	S	U-S	U-S	E												E			
		S	S	U-S	S	U-S	U-S	U-S	S						E						U			
		S	S	S	S	S	S	S	S	E	E	S	S	E		E		E		E	U			
		S	U	S	S	S	S	S	E	E	E	S	E	S		E	E	E	E	E	U			
			S		S		S		E	E	E	S	E	S		E	E	E	E		U			
	U	U	U	U	U-S	U-S	U-S	U-S	U-S						E						S			
	U	U	S	S	S	S	S	S	U-S	S		S	S	E	E		E	E	E	E	E			
	S	S	S	S	S	S	S	S	U-S						S		E	E	E	E	E			
															U-E									
	U-S	U-S	U-S	U-S	U-S	U-S	U-S	U-S	E	E	S	S-E	S-E	S-E	U-E	U-E	E	E	E	E	E	S	S	S
	S	S	S	S	S	S	U-S	U-S	E	E	S	S-E	S-E	S			E	E	E	E	E	S	S	S
	S	U	U	U	U	U	U	U	E	S	S		S				E	E	E	E	E	S		
	U	U	U	U	S	S	S	S	S	S	S	U	S		U-E	U-E	E	E	E	E	S	U	U	U
	U	U	U	U	S	S	S	S	S	U	U	S	S	S	U-E	U-E	E	E	E	E	E			
	S								S	E	S	S-E	S-E	S-E			E	E	E	E	E	S	E	S
	U	U	U	U	U	U	U	U	U	U	U	E	S-E	S-E	U-E	U-E	E	E	E	E	E	U	E	U
	1	2	3	4	5	6	7	8	1	1	2	3	4	5			1	2	3	4	3	1	2	3

on. Most of the mechanical properties in the table relate to this problem and are self-explanatory.

Ideally, an insulation should have good electrical properties as well as mechanical. In practice, good dielectrics are often protected by adding coverings of tougher materials.

In severe-service applications, such as switchgear, locomotive motors, mill motors and power tools, mechanical stress is very great. Resistance to abrasion is important when an open motor must operate in a dusty atmosphere. If the dust is iron, particles falling on the surface of the coil insulation will be influenced by the magnetic field; particles can migrate through the insulation—if it is too soft—and lower the dielectric strength.

When insulation is applied as a liquid, viscosity should be low enough to help it fill and penetrate. Dielectric oils have low viscosity to circulate freely in transferring heat from windings to case.

Chemical properties

Inorganic materials such as glass, mica, asbestos and ceramics are usually stable at high temperatures and in chemical environments. But organic insulations—most are of this type—are subject to oxidation, depolymerization (resins), hydrolysis and corrosion, and accelerated thermal degradation.

Compatibility comparisons in the table are general; there will be many exceptions. When in doubt, consult the insulation manufacturer and give him details of the expected environment in your application.

Solderability is fairly important when the equipment is to be mass produced. Good solderability means that the insulation coating will evaporate or melt without leaving a harmful deposit. No "stripping" of the conductor is needed.

Test standards for insulation

Life-to-failure tests of complete insulation systems under expected service conditions are very desirable. However, such tests are often impractical, particularly if the system must run for years.

Suitable compromise testing techniques have been developed over the years by the AIEE, ASTM (American Society of Testing Materials) and other standards-writing groups. Two of these procedures—AIEE #57 and AIEE #510—are widely used throughout the industry.

The first—Thermal Stability, AIEE Test Procedure #57, Jan '59—is known as the twisted-pair test because the insulated conductors are twisted together. It is specifically for round wire coated with enamel or film with or without varnish. Test temperatures are well above the service temperature to accelerate aging. The samples are cycled between prescribed limits for each test; thermal-degradation failure is indicated by a change in dielectric strength of the insulation (a 1000-v proof test is used). Special operating conditions such as high humidity are also covered.

The procedure also describes the method of plotting the data as logarithms of the life in hours vs the reciprocal of the absolute temperature, which usually is a straightline relationship that can be extrapolated to determine the temperature rating.

The other test is called Random-wound Machinery (motorette), Test Procedure AIEE #510 (Nov '56). It describes a simple rig resembling a portion of a random-wound motor complete with two coils, slot liners, phase insulation, varnish treatment and wedging. The motorette test can simulate temperature, mechanical-stress, moisture and electrical-potential conditions of the actual application. The procedure also describes full-scale tests of actual motors, including details of a 100%-humidity test cell (flooded floor), aging techniques, and a data extrapolation method.

MODERN INSULATING MATERIALS

Properties table on previous page covers important organic and inorganic insulation materials. Chemical terms are avoided as much as possible in the text; important chemical relationships are discussed in the box on the facing page.

Coatings on conductors

Wire enamels are varnishes applied to copper or aluminum wire in thin multilayer coats from a solution or dispersion of the varnish in water or another medium. They are the best low-voltage insulation for coils and windings, and give the most electrical protection in the least space.

Served wire (covered with a textile "roving" or tape, and varnish-treated) has greater mechanical strength, abrasion resistance, and tolerance to overloads and temperature stress. However, it is bulkier than enameled wire and has a relatively low voltage rating.

Served enameled wire combines the mechanical strength and cushioning of the serving with the good film and electrical properties of the enamel.

With improved enamels that have good mechanical strength at the higher temperatures, served wire is not always necessary—a common example is in the start windings of small motors. For very high temperatures, ceramic, polytetrafluorethylene and silicone-treated-glass coatings can do the job. And soon new organic enamels good to 200 C (390 F) and above will be available.

Liquid resins

Liquid resin is designed to stay fluid only long enough to aid its application to the equipment—filling, treating, embedding or encapsulating. Then it is converted by catalysis or heat to the final solid form.

Varnishes

Varnishes in general are chosen for their curing characteristics, flexibility, bonding, toughness and compatibility with other materials in the system. There are a great many varnish types, used for coating substrates (basic layers or sheets), filling and treating coils, bonding, surface coating and protection of windings. Baked or cured varnishes are superior to the air-dry types which are mainly used for adhesives or temporary assembly.

Dielectric properties for many insulating varnishes are usually good enough so that variations among materials will not unduly influence choice. Handling and processing—nonelectrical problems—are more important.

The Chemistry of Insulation

■ Insulation can be organic, inorganic, or semiorganic. Organic compounds are those containing combinations of carbon, hydrogen and oxygen—and sometimes nitrogen and sulfur. Most insulation is organic or based on organics. The only major inorganic materials are ceramics, mica, asbestos and glass. Silicones are semiorganic because they are built of silicon-oxygen linkages to which organic carbon-hydrogen and other radicals or groups are added.

Synthetic resins

Synthetic resins and other organics are the basis for most of the newer insulating materials—varnishes, wire enamels, encapsulating compounds, and films. Adhesives, binders, coatings and impregnants for sheet, laminate and molded insulation are also made from synthetic resins.

Synthetic resins are usually made from low-molecular-weight chemicals and monomers, which are then converted by oxidation, catalysis, heat or pressure to complex polymers with high molecular weight.

Polymerization is molecular building of polymers. Copolymers result when two or more monomers polymerize together. An example is Vinylite—a copolymer of vinyl chloride and vinyl acetate.

Linear polymers have a chain-like molecular structure, giving flexibility or thermal plasticity to the insulation. Three-dimensional polymers are stronger, more rigid, and sometimes more brittle, usually permanently "set" by heat, pressure or chemical change. Many molded plastics and baked varnishes are three-dimensional (and thermosetting) polymers. (Thermosetting materials become more rigid—"set"—with heat; thermoplastic materials soften.)

Polymerization occurs more easily in "unsaturated" than "saturated" chemical structures. Unsaturated materials contain double or triple bonds and are more reactive.

Chemical names

Chemical and commercial names for many insulating materials—particularly the synthetic resins and plastics—are nondescriptive, except to a chemist. Here is a brief explanation of the important ones (in the order of appearance in the table):

Coatings on wires—Oleoresinous refers to a material containing drying oil and resin. Formvar is a synthetic made from polyvinyl alcohol and formaldehyde—technically a "polyvinyl formal" resin. Epoxy resin is an organic synthetic with a very reactive three-member ring of two carbon atoms and one of oxygen, plus unreacted OH (hydroxyl) groups to promote cross-linking and hardening. A polyester is the product of a reaction between polyalcohols (more than one OH group) and polybasic acids (more than one COOH group). This reaction is called esterification. Typical polyesters are Mylar and Alkanex. Nylon is a polyamide—contains the C(O)NH amide group. Acrylics, made from acrylic acid, are "addition" polymers based on the reactivity of the vinyl group ($CH_2 = CH–$). Polyurethanes are the reaction products of disocyanates $R(NCO)_2$ with alcohols. Butyar is a resin and it is similar to Formvar. Teflon is an addition polymer based on tetrafluorethylene (halogen-modified ethylene). Dacron and Mylar are forms of polyethylene terphthalate—a polyester.

Liquid resins—Polyester and epoxy are described in the previous paragraph. Urethane is the reaction product of isocyanate with polyalcohol. Isocyanate is an organic salt based on isocyanic acid.

Varnishes—Phenolics are resins formed by the reaction of phenol and formaldehyde. Alkyds are polyesters modified with drying oils such as cottonseed, castor and linseed. Silicones are semiorganic—described in the first paragraph.

Films—Teflon is described under wire coatings. Cellulosics are compounds such as cellulose acetate butyrate and polyethylene. They are related to cellophane, which is a pure cellulose film. Polyethylene—more is sold than any other plastic—is a polymer of ethylene and is a lightweight, thermoplastic synthetic resin. (Ethylene is obtained from coal gas or petroleum. It can also be made by the reaction of concentrated sulfuric acid and alcohol.) Mylar is an example of a polyester, described before.

Plastic tape—Vinyls are thermoplastic resins formed by the polymerization of vinyl compounds such as vinyl acetate. Polyvinylchloride is a special vinyl resin—known as PVC and used widely because it can be compounded with many materials in a variety of ways to give different properties, colors, shapes and forms. Irrathene is polyethylene irradiated to enhance its properties. (Only a few insulating materials are improved by nuclear radiation—most others deteriorate.)

Textiles—Dacron-glass is simply a cloth woven with Dacron in the "warp" direction and glass in the "fill" or cross direction.

Ceramics—Steatite is a material originally made from clays, and has the composition of talc or soapstone. Alumina is a mineral, aluminum oxide. Porcelain is made from clay, quartz, and feldspar.

Oils—Askarels are fire-resistant chlorinated organic liquids developed as dieelectrics and heat-transfer media for transformers and other applications. ■

Asphalt-base varnishes are cheapest and have fairly good electrical properties, initial flexibility and water resistance; but they are limited in temperature. Phenolics and epoxies are good bonding materials. Alkyds and polyesters with some exceptions are superior in aging and high-temperature endurance, inferior in moisture resistance and bonding. Silicones can stand high temperatures but are relatively poorer mechanically.

Filled resins and varnishes

Filled varnishes are used as paints or enamels (for industrial coating on frames and tanks and surface protection of windings). They give a thick, durable, continuous film relatively impervious to moisture, dirt, oil, and metallic dust.

Compounds of varnishes and liquid resins with fillers serve as putties to fill end windings of motors, hold leads, and pot or encapsulate coils and complete components. (They are not molded plastics: they are not molded under pressure.) Proper fillers can improve heat-transfer characteristics.

test continued, page 51

TYPICAL APPLICATIONS FOR INSULATION

DC MOTORS AND GENERATORS—Coated wire (Formvar, polyester, Butvar, cotton, glass, asbestos, Dacron-glass); liquid resins (polyester, epoxy); varnishes (asphalt, phenolic, epoxy, alkyd, polyester); filled resins (paint, putty, filling compound, treating compound, encapsulating compound); papers (pressboard, vulcanized fiber, asbestos, mica paper); plastic sleeving (polyvinylchloride) textiles (cotton, fiberglass, Dacron-glass, asbestos); flexible laminates (mica with film, mica with glass cloth); rigid laminates (paper, cotton, asbestos, glass, mica); molded plastics (thermosetting).

MINING, LOCOMOTIVE MOTORS—Coated wire – (Formvar, epoxy, polyester, glass, asbestos, Dacron-glass); liquid resins—(polyester, epoxy); varnishes (epoxy, alkyd, polyester); filled resins (paint, putty, filling compounds); papers (asbestos, mica paper); plastic tape (silicone rubber); textiles (fiberglass, silicone on glass, silicone on Dacron-glass, asbestos); flexible laminates (mica with film, mica with glass cloth, polyester film); rigid laminates (asbestos, glass, mica); molded plastics (thermosetting).

AC MOTORS, RANDOM WOUND—Coated wire (Formvar, epoxy, polyester, nylon, Butvar, glass Dacron-glass); liquid resins (polyester, epoxy, urethane); varnishes (phenolic, epoxy, polyester, silicone, acrylic); Filled resins (paint, putty, filling and encapsulating compounds); papers (asbestos, mica paper); films (polyester); plastic tape (polyvinylchloride, silicone rubber); textiles (cotton, fiberglass, silicone on glass, Dacron, Dacron-glass, silicone on Dacron-glass, asbestos); flexible laminates (paper with film, paper with film and varnished cloth, asbestos with film, asbestos with glass cloth, mica with film, mica with glass cloth, polyester film); rigid laminates (paper, cotton, glass); molded plastics (thermosetting).

AC MOTORS, FORM WOUND—Coated wire (Formvar, epoxy, polyester, glass, asbestos, Dacron-glass); varnishes (asphalt epoxy, polyester, silicone); filled resins (paint, putty, filling compound); papers (mica paper); films (polyester); plastic tape (Irrathene, silicone rubber); textiles (cotton, fiberglass, silicone on glass, Dacron, Dacron-glass, silicone on Dacron-glass, asbestos); flexible laminates (paper with film and varnished cloth, asbestos with film, asbestos with glass cloth, mica with film, mica with glass cloth, polyester film); rigid laminates (paper, glass); molded plastics (thermosetting).

FHP MOTORS—Coated wire (Formvar, epoxy, polyester, nylon, acrylic, polyurethane, cotton, glass); liquid resins (polyester, epoxy, urethane; varnishes (asphalt, phenolic, epoxy, polyester, silicone); filled resins (paint, putty); papers (pressboard, vulcanized fiber); films (cellulose ester, polyester); plastic tape (polyvinylchloride); textiles (cotton, asbestos); flexible laminates (paper with film, polyester film); rigid laminates (paper, asbestos); molded plastics (thermosetting).

AUTOMOTIVE MOTORS—Coated wire (oleoresin, Formvar, epoxy, polyurethane, cotton, glass); varnishes (phenolic, epoxy, polyester); papers (pressboard, vulcanized fiber); films (polyester); textiles (cotton, asbestos); flexible laminates (paper with film); rigid laminates (paper); molded plastics (thermosetting).

HERMETIC MOTORS—Coated wire (Formvar, polyester, acrylic, cotton, glass); varnishes (polyester, acrylic); films (polyester); textiles (cotton); flexible laminates (paper with film, polyester film).

SPECIALTY TRANSFORMERS—Coated wire (Formvar, epoxy, polyester, glass); liquid resins (polyester, epoxy, urethane); varnishes (phenolic, epoxy, polyester, silicone); filled resins (filling and encapsulating compounds); papers (asbestos, mica paper); films (Teflon, cellulose ester, polyethylene, polyester); plastic (Irrathene, silicone rubber); textiles (fiberglass, silicone on glass, silicone on Dacron-glass, asbestos); flexible laminates (paper with film, paper with film and varnished cloth, asbestos with film, asbestos with glass cloth, mica with film, mica with glass cloth, polyester film); rigid laminates (asbestos, glass); molded plastics (thermosetting); oils (silicone).

INSULATORS, BUSHING—Papers (kraft, asbestos, mica paper); flexible laminates (paper with film, asbestos with film, asbestos with glass cloth, mica with film, mica with glass cloth); rigid laminates (paper, asbestos, glass); molded plastics (thermosetting); ceramics (porcelain, glass).

INDUSTRIAL CAPACITORS—Liquid resins (polyester, epoxy, urethane); filled resins (encapsulating compound); papers (kraft, mica paper); films (Teflon, polyethylene, polyester); rigid laminates (paper, glass); molded plastics (thermosetting); ceramics (mica); oils (mineral oil, askarel, silicone).

SWITCHGEAR—Varnishes (phenolic); papers (pressboard, vulcanized fiber, asbestos); plastic sheet (vinyl, Irrathene, silicone rubber); textiles (cotton, fiberglass, silicone on glass, Dacron-glass, silicone on Dacron-glass, asbestos); rigid laminates (paper, glass); molded plastics (thermosetting); ceramics (porcelain); oils (mineral oil, silicone).

CONTROL WIRING AND DEVICES—Coated wire (oleoresin, Formar, epoxy, polyester, glass, asbestos); liquid resins (polyester, epoxy, urethane); varnishes (phenolic); papers (vulcanized fiber, asbestos, mica paper); films (cellulose ester, polyester); plastic tape (vinyl, Irrathene); textiles (cotton, fiberglass, Dacron-glass, asbestos; flexible laminates (polyester film); rigid laminates (paper, glass); molded plastics (thermosetting).

METERS, INSTRUMENTS—Coated wire (oleoresin, Formvar, epoxy, polyester, cotton, glass); liquid resins (polyester, epoxy, urethane); varnishes (asphalt, phenolic, epoxy); filled resins (encapsulating compound); papers (kraft, mica paper); films (Teflon, cellulose ester, polyester); textiles (cotton, fiberglass, Dacron-glass); flexible laminates (paper with film, polyester film); rigid laminates (paper, cotton, glass); molded plastics (thermosetting).

INDUSTRIAL WIRE—Filled resins (paint, filling and treating compounds); papers (rope, asbestos); textiles (cotton, asbestos).

MAGNET WIRE, ENAMELED—Coated wire (oleoresin, Formvar, epoxy, polyester, nylon, acrylic, polyurethane, Butvar, Teflon); flexible laminates (polyester film).

MAGNET WIRE, SERVED—Coated wire (oleoresin, Formvar, epoxy, Teflon, cotton, glass, asbestos, Dacron-glass); filled resins (paint); papers (kraft); films (Teflon, polyester); textiles (cotton, fiberglass, Dacron-glass, asbestos); flexible laminates (polyester film).

COMMUNICATION WIRE—Coated wire (oleoresin, Formvar, nylon, polyurethane); filled resins (paint); films (cellulose ester, polyethylene, polyester); plastic tape (polyethylene); flexible laminates (paper with film).

HOOKUP WIRE—Filled resins (paint); films (polyethylene); plastic sleeving (vinyl, polyethylene, polyvinylchloride).

PRINTED CIRCUITS—Rigid laminates (paper, glass); molded plastics (thermosetting).

ELECTRONIC CAPACITORS—Liquid resins (polyester, epoxy, urethane); filled resins (paint, encapsulating compound); papers (kraft, mica paper); films (Teflon, polyethylene, polyester); rigid laminates (paper, mica); molded plastics (thermoplastic, thermosetting); ceramics (mica).

Important filled-resin properties are: bond strength, ease of curing and bonding, freedom from electrolytic corrosion, little tendency to de-gel, stability under moisture and heat, and tolerance to high voltage and high frequency at high temperature and humidity in electronic applications.

For patching or filling, there are special semifluid materials. Examples are Dow Corning Silastic paste and GE silicone-rubber compound, which are both RTV (room-temperature vulcanizing). They change to rubbery solids with catalysts.

Papers

Untreated paper, various krafts, rag paper, fish paper and vulcanized fiber are still very important components of transformers, capacitors, cable and switchgear. In oil-filled equipment, carefully chosen papers and oils give outstanding performance at high voltage in temperatures up to 115 C (240 F) if moisture and air are kept out.

Films and glass fiber are now becoming competitive with paper. Vulcanized fiber (a pressboard) is a dielectric with good arc resistance and is also a good structural material for nonelectric jobs. Asbestos and mica papers combined with sheet-insulation or film backings and facings are useful as tapes, wrappers, slot insulation, coil separators, and layer insulation. Asbestos paper is reasonably temperature-resistant, but is useful mainly for mechanical and economic reasons; mica paper gives superior electrical and thermal performance.

Films

Toughness, tear resistance and controlled shrink during elongation are important properties for film. Mylar meets these requirements well, and has good insulation properties too. Other suitable materials are cellulose acetate butyrate and polyethylene. Polyethylene has excellent electrical properties but is limited in temperature and is damaged by oil and solvents.

Untreated fabrics make good ties, facings, and temporary tapings. With varnish they can be laminated.

Coated fabrics are more common. Cotton is the oldest; fiberglass and synthetics such as nylon and Dacron are more recent. Each can be coated with any of the varnishes or resins listed in the Properties table.

For low voltage—up to 6000 v—coated fabrics work as straight and bias tapes, sheets, and wrappers. Varnished cambric has been a standard for years in coil separators, pads, layer-insulation, wire and cable wrappings, and flexible composites for slots. Bias cloth tapes have stretch and can conform to irregular coils and shapes. Straight-weave black varnished cloth is widely used for laminated cable in the 500 to 15,000-v range. Thin varnished silk is handy for meters, instruments and relays. Fiberglass and Dacron-glass have superior temperature, moisture, and chemical resistance, and have replaced cotton in many jobs. Nylon cloth has excellent moisture resistance. Rayon is strong and can replace silk in many instrument applications.

Small amounts of heavy cloths are used for mechanical duty such as protective cushions under connections, banding, collars of field coils, and gaskets. Varnished cloths are used as backing for Mylar and mica.

Flexible laminates

Composites and tapes are combinations of sheet insulations, bonded with varnish or resin. Tapes are usually from 0.002 to 0.010 in. thick; flexible sheets and composites are from 0.010 to 0.025 in. thick.

Tapes insulate form-wound coils for large motors and generators. Mica and mica paper are chosen where temperature is high and voltage endurance is needed.

Temperature performance of a composite depends on the proportions of class *A*, *B*, *F* and *H* constituents. A small amount of paper or other class *A* material is permissible with mica and other higher-temperature materials. Glass cloth, Dacron and Dacron-glass substrates are used with varnishes, resins and silicone rubbers more and more in class *B*, *F* and *H* applications, giving improved electrical strength, moisture resistance, and thermal endurance.

Varnished absestos cloth withstands heat and has flexibility—useful in heavy-duty shock pads and collars in class *B* applications. Varnished glass cloth has high crease- and crush-resistance.

Silicon-resin, silicone-rubber-coated glass and Dacron-glass have outstanding thermal endurance—to over 200 C (390 F). They also have good dielectric properties, low power factor, flexibility, and resistance to moisture and chemicals at both low and high temperatures. One application is for high-temperature cable (class *B*, *F* and *H*) in motors and generators with sealed insulation.

Polyester-coated glass cloth has outstanding mechanical strength, with class *F*+ performance for layer, phase, slot and coil wrappers and supports.

Rigid laminates

Rigid laminates give mechanical and dielectric strength to instrument parts, printed circuits, spool bodies, spacers, mechanical moving parts, switches.

Ceramics

Ceramics and glass are common as insulators in high-v applications—lightning arresters, bushings, terminals, outdoor distribution and central stations. They have rigidity, hardness, mechanical strength, arc resistance, resistance to heat and humidity, and dimensional stability. Electrical strength and dielectric-loss characteristics are favorable even at extremely high temperatures.

For REPRINT of above article, just check 599 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: The problem of insulating and protecting electrical equipment has been explored previously:

Survey of Encapsulating Systems, Sep 19 '60, p 68—Describes encapsulating materials such as epoxy, polyurethane, polyester, silicone, polysulfide rubber, alkyd and vinyl, and gives design tips for encapsulation with foam, liquid, gel and solid resin.

High-temperature Electrical Equipment, Sep 26 '60, p 56—Latest developments in motors and coils to run at 1000 F. The served-glass insulation, however, is in lab stage only.

Hot Solenoid, Jan 6 '58, p 61—Fiberglass insulation lets rotary solenoid operate 300,000 times in 48 hr at 500 F.

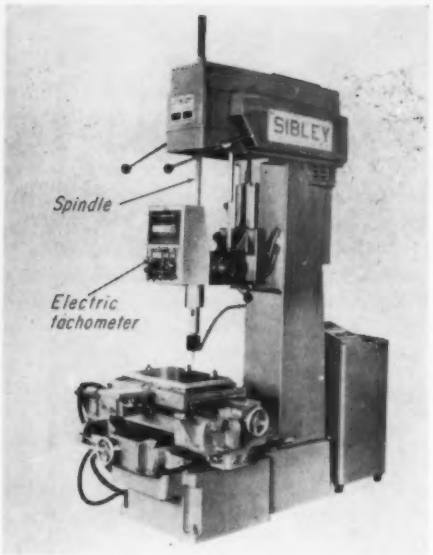
Immersed Motors, Sep 15 '58, p 80—An underwater motor can be canned, potted or given sealed-in fluid.

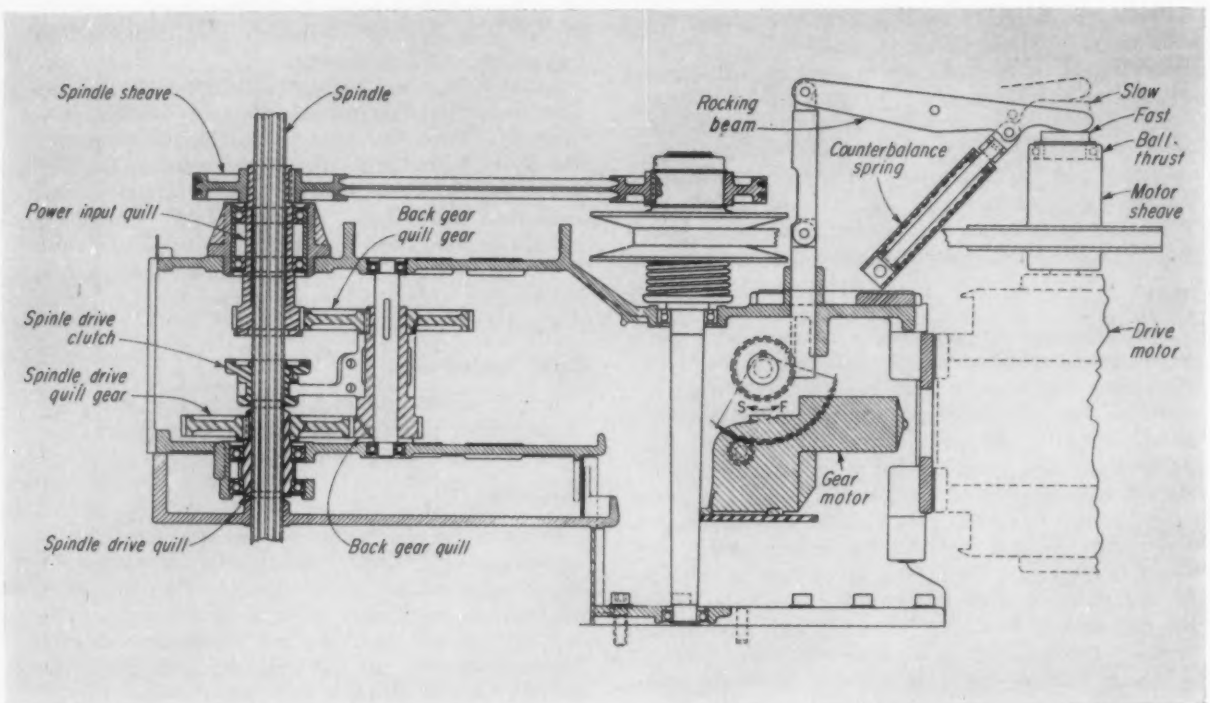
—Franklin D Yeaple

PRODUCT DESIGNS

Pushbutton Selects Exact Speed Quickly

Motor-controlled spindle-speed selection permits pushbutton control. Belts for high speeds and gears for high torque are combined in variable-speed power transmission.



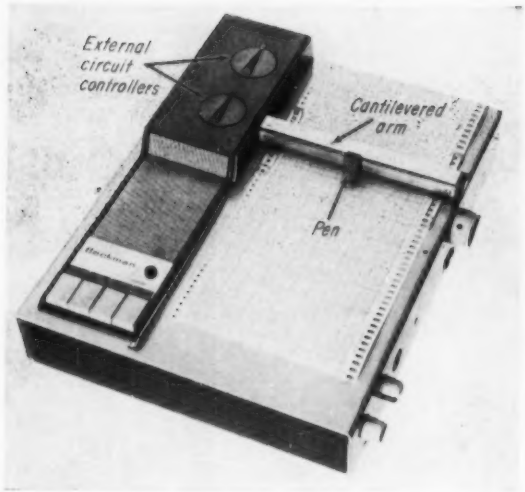


INFINITELY VARIABLE V-belt transmission is used for direct drive between motor and spindle for higher speeds. For lower speeds a back-gear system is interposed between transmission and spindle. Variable-speed transmission and back gears both have a reduction of 6 to 1 in order that the fastest speed in back gear (low range) shall be equal to the slowest speed in belt drive (direct). This eliminates any gap between highest and lowest spindle speeds.

Transmission speed changes are controlled by movement of upper half of the motor sheave. Spring-loaded, variable-diameter sheave on countershaft maintains belt tension as sheave ratio is altered. Rocking beam contacts thrust bearing to control movement of upper flange and effective diameter of motor sheave. A switch-controlled, 9-rpm, reversible gear motor drives the rocking beam through a gear segment and rack. Double worm reduction makes gear motor self-locking when shut off. Electric tachometer permits operator to observe spindle speeds during operation or setting.

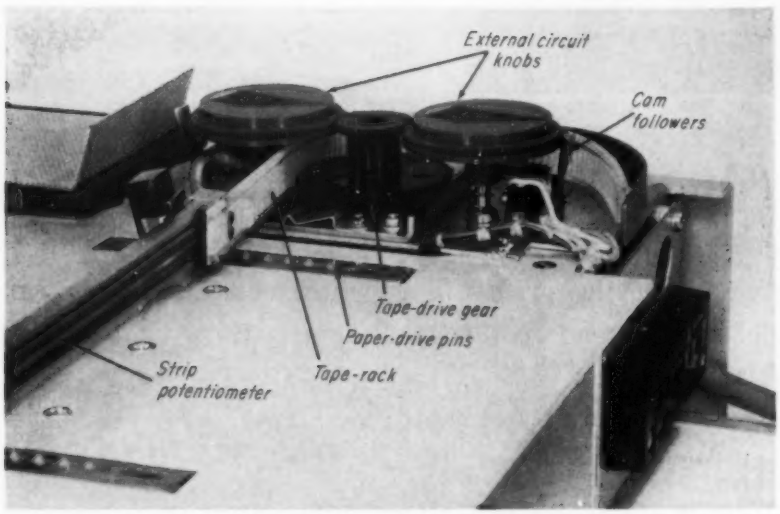
With the back gears engaged, spindle is driven by the back-gear quill and quill gears. When the back-gear control lever is shifted, the back gears are lifted out of mesh and the spindle clutch engaged. Teeth on upper edge of the internally splined clutch engage teeth on bottom of the input quill, locking the spindle sheave to the spindle. A mercury governor prevents clutch engagement until motor speed is slowed almost to a stop.

PS . . . The 40-in. swing drilling machine uses punched metal tape for automatic programming of table positions. All operator controls are placed on a Drilling Information Center panel at eye level. Spindle drive and feed mechanism were designed by Prof Carl C. Stevason, Dept of Mechanical Engineering, Univ of Notre Dame, for Sibley Machine and Foundry Corp, South Bend, Ind.



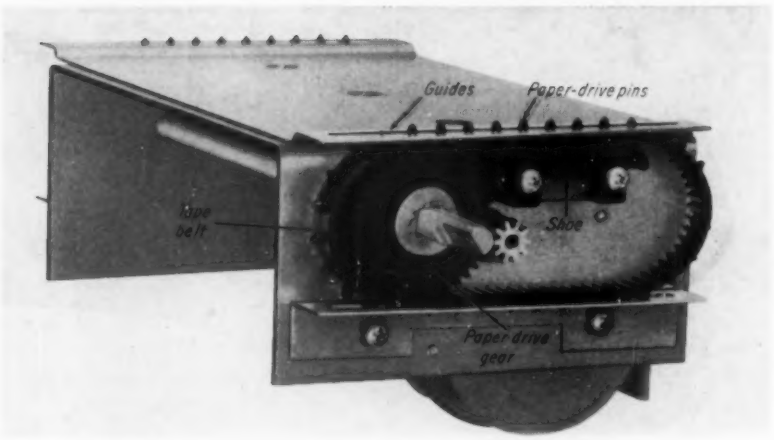
Geared Tapes Drive Recorder

Strip potentiometer wiper-contact is mounted on moving pen to eliminate backlash produced by usual mechanical linkages. Cantilever arm eases paper loading, allows use of circular or oversize charts.



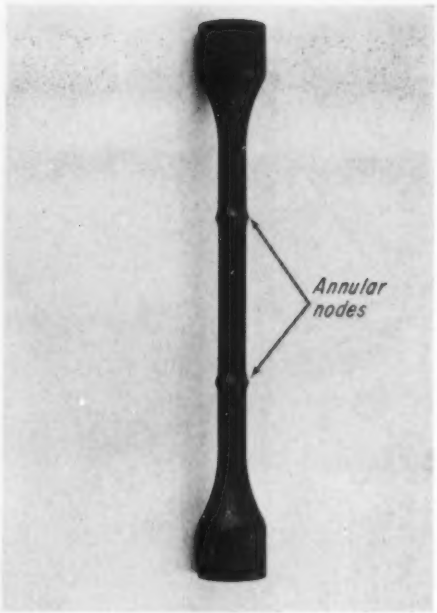
FLEXIBLE TAPE-RACK of polypropylene drives the recording pen back and forth on the cantilevered beam. Wiper in back of pen contacts strip potentiometer to indicate null position without mechanical linkages. Strip potentiometer is supplied by a stable reference voltage from a mercury cell. Input signal voltage is compared to voltage tapped off strip potentiometer and difference between voltages is balanced out by the servo-driven wiper.

External circuits can be controlled by the spring-loaded knobs meshed with the pen drive. Cams on their lower edges actuate switches at preselected limits of pen travel. Actuation limits are selected by depressing the knob to disengage gear teeth, rotating knob to desired position and releasing to reengage pen-drive gear.



PAPER DRIVE uses flexible nylon tape-belt molded with gear teeth on the inner surface and paper-drive pins on the outer. Nylon gear pulls belt over shoe; guides keep pins in line and in contact with gear. Marks on belt and drive gear ensure assembly with proper index and belt slack. Elongation or tear-out of recording-paper sprocket holes is eliminated because at least 9 pins are engaged at all times. Teflon coating on belt shoe provides permanent, stain-free lubrication.

PS . . . Recorder is used with a variety of sensing elements for the measurement of such variables as temperature, pH, frequency, heat, solution conductivity, pressure, strain, speed and light-sensitivity. Instrument monitor dc signals in 0 to 100-mv range, provides 5-in. pen travel and achieves repeatability of better than 0.35%. Pen response is 1.0 sec full scale. Potentiometric Strip-Chart Recorder is produced by Beckman Instruments Inc, Fullerton, Calif.

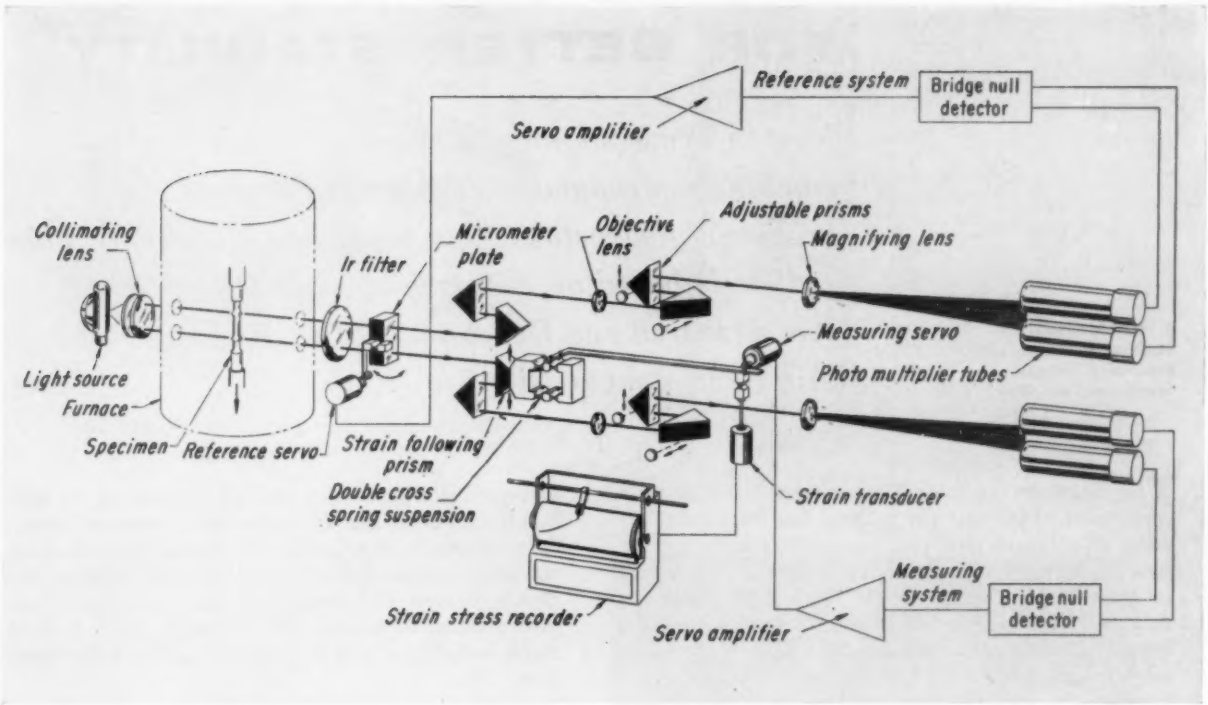


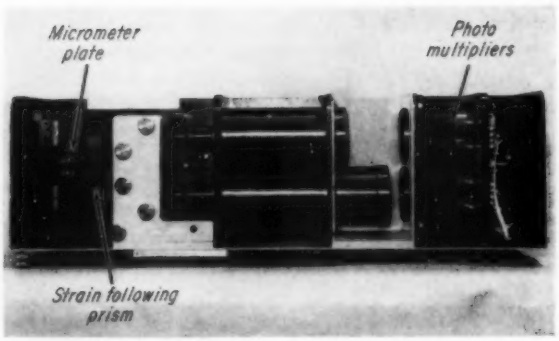
It Measures Strain at 5000 F

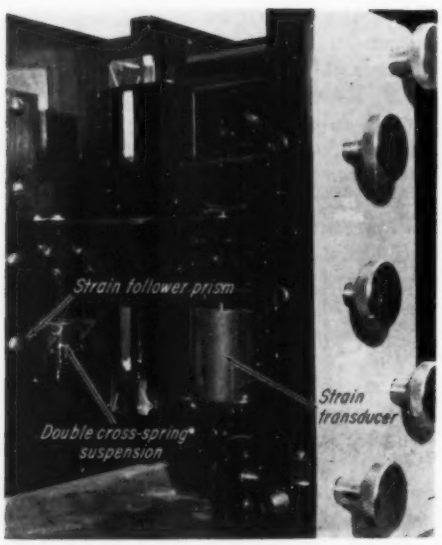
Shadows thrown by annular nodes on hot test specimen are tracked by moving prisms in a light-sensitive servo system. Output may be read on meter and automatically plotted, with stress as abscissa.

LIGHT SOURCE and collimator are at left, sensor assembly at right of frame. Frame structure encircles standard extension-compression tester which would have a windowed furnace for high-temperature runs. Console encloses power supply, servo amplifiers and meter readout.

PS . . . Optical extensometer was designed to work with any tension or compression test machine fitted with a furnace for high-temperature strength tests. Up to 3000 F, the specimen nodes project shadows. Above 3000 F and to 5000 F, it emits enough light so that the tubes will sense the bright image. The extensometer will follow strain rates as high as 0.1 in./min. with an accuracy of 0.0001 in. Sensitivity is 0.0001 in./in. Optical extensometer, developed by R J Vodra, is being manufactured by Coleman Engineering Co, Torrance, Calif.







SHADOWS OF ANNULAR NODES on the test specimen are projected into the sensor-box optical systems. Filter stops infrared rays emitted by the specimen at high temperatures. Each shadow is projected on the faces of two photomultiplier tubes. In null position, the shadow is equally distributed between the two tubes, and their output signals are in balance. When the shadow moves, signal unbalance is detected by a bridge and the error amplified to drive a servomotor. The servo deflects optical components to recenter the shadow on the tubes.

Stress is applied to lower end of specimen; upper end is held stationary. Strain to be measured is the relative deflection between the two nodes. Since both nodes move in the direction of applied stress, movement of upper node must be subtracted from movement of lower. The deflection detector system for the upper node drives the micrometer plate servo which shifts both shadows in the same direction and by the same amount. Hence movement of the upper shadow will be subtracted from movement of the lower one before it even reaches the first prism.

When movement of the lower node is detected by its photomultiplier tubes, the servo drives a prism that returns the shadow to null. At the same time, the servo drives a strain transducer whose signal output is fed to a meter and to a strain-stress recorder.

Each optical system includes a pair of manually adjustable prisms for zeroing-in shadows before the test. The prisms move in dovetails and the upper two are driven by knobs with threaded shanks moving in tapped holes in the front panel. All pivots are of the crossed-spring type to reduce friction and hysteresis.

HYBRID GAS BEARINGS FOR BETTER STABILITY

New information on gas bearings shows how to combine hydrodynamic design parameters and minimum hydrostatic flow for stable operation. This article is based on research sponsored by the Air Research and Development Command, Wright Air Development Div.

P H STAHLHUTH
Manager, mechanical section
Sundstrand Turbo Div
Sundstrand Corp, Denver

The simplicity of hydrodynamic and the high load capacity of hydrostatic gas bearings has led to development of a hybrid type that incorporates advantages of both. The purpose is to overcome the major problem in hydrodynamic gas bearings, which is instability at light loads and high speeds. Under these conditions the bearing tends to run with reduced eccentricity and is subjected to a condition where film pressure is not in line with the load direction. This creates instability in a manner that makes the center of rotation whirl around the bearing center at half the shaft speed—"half-speed whirl."

The difference between the two parent types is this:

- The hydrostatic type uses an external source of gas, and this means pressure can be increased as needed.
- In hydrodynamic type the pressure for load-supporting gas is generated by dynamic action of the bearing itself.

Design parameters for either hydrodynamic or hydrostatic bearings can be developed by analysis, but a test rig is needed to obtain parameters for maximum stability of an empirical combination of the two systems. This is why, after developing several test rigs to investigate what goes on in hydrodynamic thrust bearings, the design shown in Fig 1 was adopted. With it, we can study half-speed whirl and other stability phenomena, in addition to load capability. It incorporates all previous experience relative to instrumentation, mounting calibration, secondary effects due to rotor assembly details, and effects of rotor OD runout on data reduction. It is instrumented to record film thickness, rotor motion, speed, radial load, film pressure and lubricant flow pressure.

Another important feature is the simulation of zero-gravity operation by rotating the bearing axis into the vertical plane. High loading conditions up to 10 g are provided by means of a pneumatic loading system.

Bearing details were designed to simulate a closed-cycle turbo-alternator for long-duration space operation. The tester has a simple cylindrical rotor, which duplicates the bearing geometry and weight of the alternator rotor, Fig 2. A knurled section in the rotor center provides turbine buckets, and a ring of nozzles, connected to a compressed-air line, does the driving. This turbine system reduces the noise level, and eliminates extraneous bearing loads due to turbine torque.

A single speed-indicating dimple is located on each end of the rotor under the displacement transducer to correlate rotor motions with a particular spot on the rotor. These rotor motions are recorded on an oscillograph with a paper speed of 115 in./sec. The rotor OD is held concentric with ID within 0.000,020 in. total indicated reading to eliminate runout effects from the recorded data. Four capacitance-type proximity transducers are installed rigidly in the shaft-mounting fixture to measure rotor OD motions in the vertical and horizontal planes at each end of the rotor.

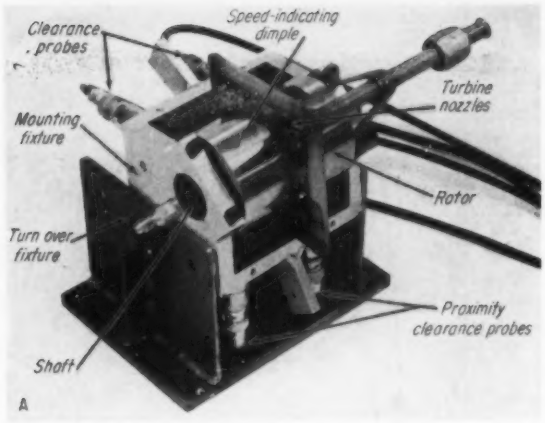
Photocon Research Corp proximity probes measure film thickness within the bearing at two points 90° apart. The outputs of these probes are fed through P.R.C. Dynagages and displayed on an X-Y plotter, with vertical clearance on Y axis and horizontal on X axis.

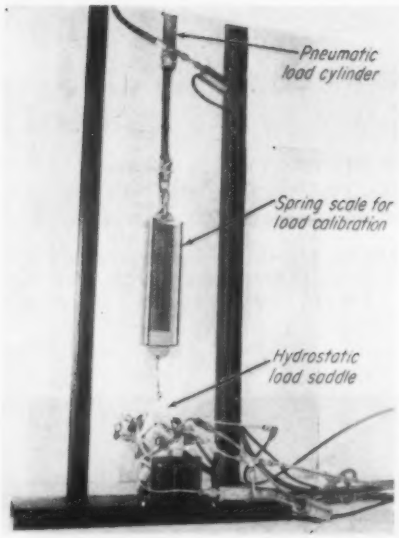
With perfectly linear calibration of clearance versus output, the bearing diametral clearance would be displayed as a circle on the X-Y plot, with a scale diameter of 0.0027 in. (plus diametral growth at operating speed). Any nonlinearity of the calibration results in a simple conformal transformation to a distorted circle.

The simplified presentation of the measured film

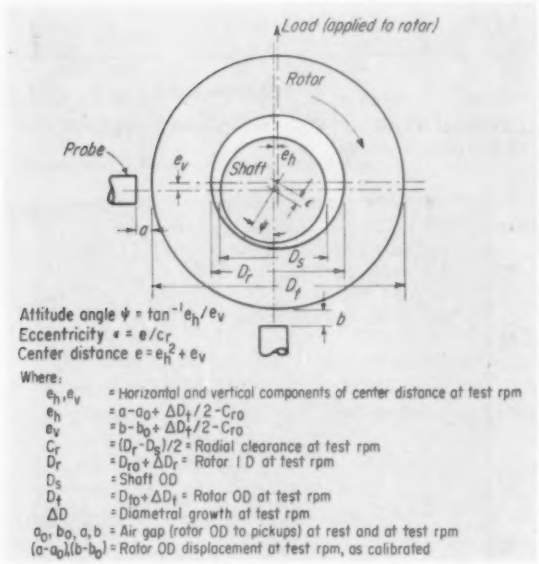
SYMBOLS

b	— Bearing length, in.
C_d	— Diametral clearance, in.
C_r	— Radial clearance, in.
D	— Diameter, in.
H	— Design parameter $= 6\nu\omega r^2/P_e k C_r^2$
k	— Ratio of specific heats
L	— Load parameter $= W_1/(kP_e bD)$
N	— Speed, rpm
N_c	— Max stable speed, rpm
P_e	— Ambient pressure, psia
W	— Bearing load, lb
W_1	— Bearing load without end flow, lb
W/W_1	— End-flow factor
ϵ	— Eccentricity ratio
ν	— Absolute viscosity, lb sec/in²
ω	— Angular velocity, rad/sec $= 2\pi N/60$
ψ	— Attitude angle, deg

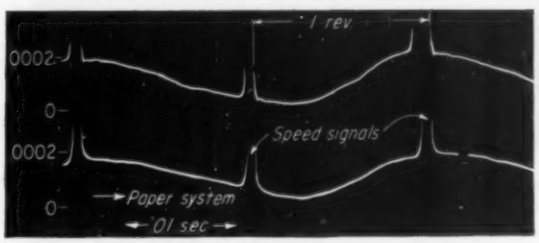




1 . . TEST RIG for gas-bearing stability shows assembly (A); hydrostatic load saddle with instrumentation (B).


Load (applied to rotor)
Rotor
Probe
e_v
Shaft
e_h
ψ
c
a
D_s
D_r
D_t
b
Attitude angle $\psi = \tan^{-1} e_h/e_v$
Eccentricity $\epsilon = e/c_r$
Center distance $e = e_h^2 + e_v$
Where:
e_h, e_v = Horizontal and vertical components of center distance at test rpm
$e_h = a - a_0 + \Delta D_t/2 - C_{ro}$
$e_v = b - b_0 + \Delta D_t/2 - C_{ro}$
$C_r = (D_r - D_s)/2$ = Radial clearance at test rpm
$D_r = D_{ro} + \Delta D_r$ = Rotor I D at test rpm
D_s = Shaft OD
$D_t = D_{to} + \Delta D_t$ = Rotor OD at test rpm
ΔD = Diametral growth at test rpm
a_0, b_0, a, b = Air gap (rotor OD to pickups) at rest and at test rpm
$(a-a_0)(b-b_0)$ = Rotor OD displacement at test rpm, as calibrated

2 . . GEOMETRY and test relationship of parameters—load, rotation and film thickness.



3 . . TWO SPEED SIGNALS PER WAVE show half-speed whirl (unstable operation) at 3000 rpm, horizontal axis for $D = 1.00$ in., $b = 3.00$ in., $C_d = 0.00030$ in., $W = 2.50$ lb.

thickness eliminates the data-reduction process and permits a direct understanding of the location of the center of rotation and the magnitude of minimum film thickness and attitude angle.

The shaft-mounting fixture is supported in a turnover stand so that each pair of transducers can be calibrated in the vertical plane. Fine-pitch screw jacks are built into the mounting fixture to raise and lower the rotor through its diametral-clearance range. Hydrostatic thrust pads positioned in each end of the fixture center the rotor and permit investigation of zero-gravity stability by running with the shaft vertical. The 2.50-lb rotor is supported on a 1-in.-OD shaft 3 inches long. A graphite shaft was chosen to eliminate rotor damage during breakdown of the gas film.

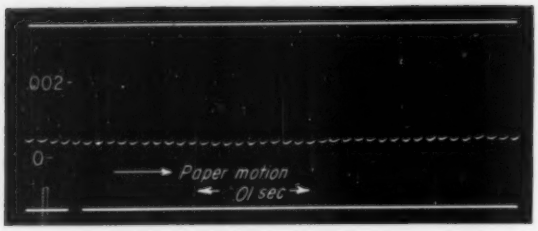
COMPARISON — HOW PARAMETERS AFFECT MAX STABLE SPEED

Parameter	No. 1 Bearing	No. 2 Bearing
b	3.000	0.500
C_r	0.000,15	0.000,85
D	1.000	1.000
H	44.0	0.565*
r	0.500	0.500
P_a	14.7	14.7
W	2.50	1.25
W_1	2.80	15.6
W/W_1	0.90	0.08
b/D	3.00	0.500
ϵ	0.02	0.83
L	0.045	1.52
N_s	3000	19,800

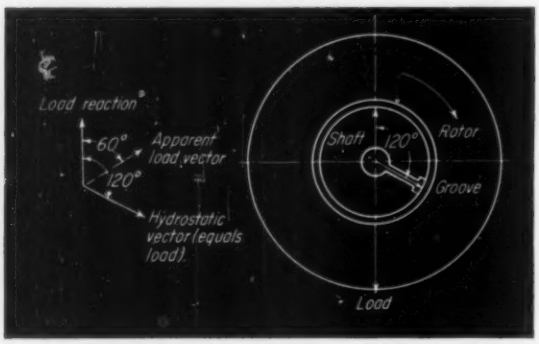
* 0.512 at Max. Safe Speed of 1800 rpm

Bearing parameters for stability

Stability depends on suitable selection of bearing parameters as shown by the following series of tests. The table above shows two sets of bearing parameters and the maximum stable speed for each. Instability, or half-speed whirl, appears graphically on the oscillograph trace, Fig 3, when the large-amplitude sinusoidal waves



4 . . UNIFORM SPEED SIGNALS—one per revolution—show stable operation at 48,000 rpm, horizontal axis for $D = 1.00$ in., $b = 0.5$ in., $C_d = 0.0027$ in. static (0.0028 in., running), $W = 1.25$ lb.



5 . . BEST LOCATION OF SLOT and vector analysis of combined effect of vertical load and pressurized slot.

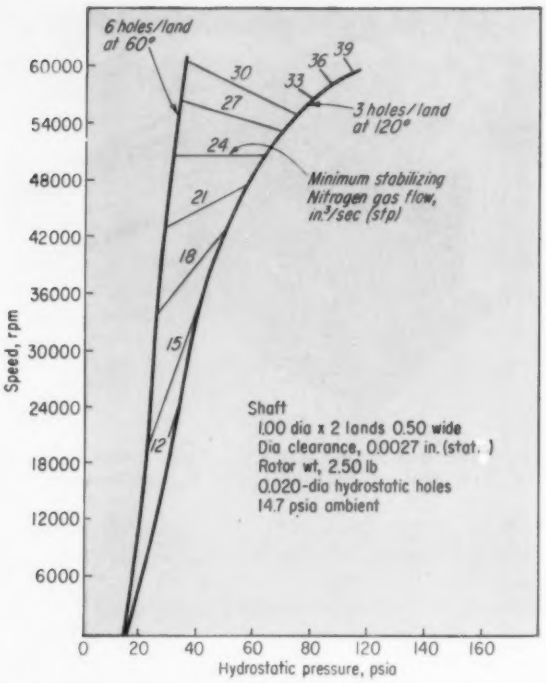
have a frequency one-half the rotor speed, as indicated by the presence of two speed signals per wave.

The eccentricity ϵ in the table was calculated from Ausman's method (see "How to Design Hydrodynamic Gas Bearings," *PE*—Nov 25 '57, p 102). In bearing No. 1, compressibility effects predominate and hydrodynamic theory does not apply for values of H greatly in excess of 1.0. This bearing showed instability at speeds above 3000 rpm. The more advantageous results of bearing No. 2 with safe stable speed of 18,000 rpm suggests the possibility of attaining stability at 48,000 rpm by further increasing the clearance to maintain an $H = 0.512$ at the higher speed. Thus, solving for C_r in the equation for H (see symbols):

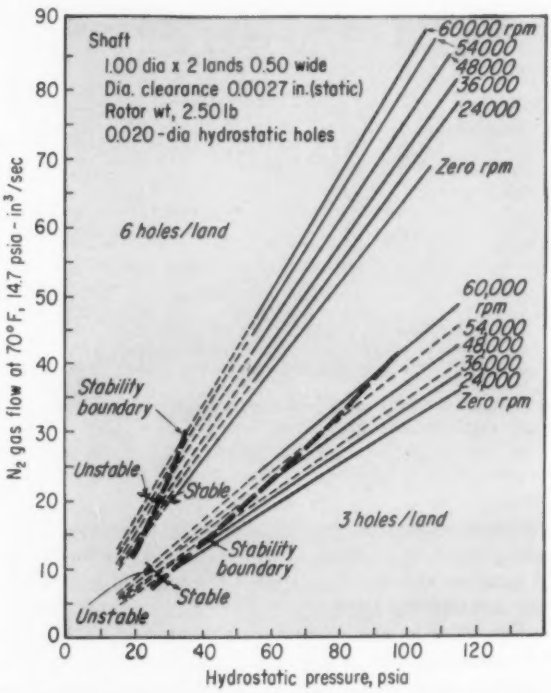
$$C_r = \sqrt{\frac{6 \times 27 \times 10^{-10} \times .5025 \times 0.25}{14.7 \times 0.512 \times 1.4}} = 0.0014$$

or $C_d = 0.0028$

To test this assumption, a graphite shaft was prepared with $C_d = 0.0027$ in. (static) and two bearing lands of 0.5 in. length, other parameters being the same as for bearing No. 2. The calculated growth of the rotor ID at 48,000 rpm is approximately 0.001 in. This increase in bearing clearance with increasing speed is an advantage that occurs in fixed shaft-rotating bearing configurations. During startup the system operates at its minimum diametral clearance, permitting attainment of hydrodynamic action at low speeds. As speed increases, the clearance also increases, delaying the onset of instability.

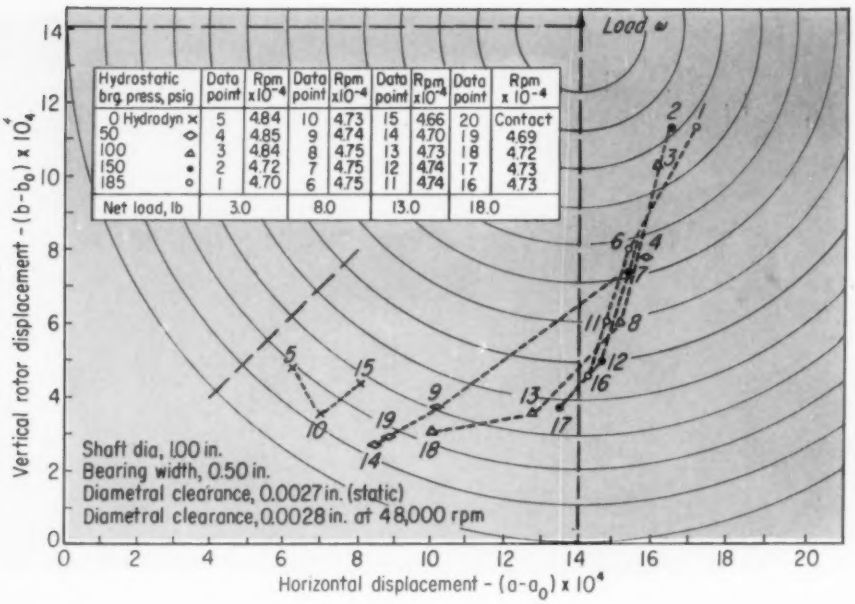


6 . . ZERO-G STABILITY for bearings with various number of hydrostatic holes.



7 . . TEST RESULTS give gas flow for stable operation at various pressures for 3- and 6-hole configurations. Heavy dash lines represent minimum flow conditions for stable operation.

The results showed stability at all speeds up to 63,000 rpm, both during loading of the test-rig turbine and during coasting. Typical oscillograph traces made by this



8 . . VERTICAL AND HORIZONTAL DISPLACEMENTS for various test points are in line with load direction at high hydrostatic pressures, but at low pressures (hydrodynamic operation) they are at 90° to the load.

bearing, Fig 4, show sharp spikes of one per revolution, indicating uniform rotation without any whirl.

Operation under various loadings

Having developed hydrodynamic bearing parameters with stability at one-g operation (shaft axis in horizontal plane) it was desirable to know the operating characteristics under loading conditions varying from zero-g to 10-g. With zero-g operation (shaft axis in vertical plane) tests showed that lack of any radial load results in instability at very low speeds. This indicated a need for supplementary hydrostatic pressure and resulted in the development of an asymmetrically grooved shaft through which gas supply is introduced.

For zero-g operation, test results showed that a pressure of 26 psig was required to stabilize this shaft at 60,000 rpm. For one-g operation the same pressure was maintained and the shaft was rotated through 360° in small steps, in the direction of the rotor rotation. At zero degrees (straight up) the rotor was well supported hydrostatically with the 26 psig, but the limiting speed was only 8000 rpm. The best slot position occurred about 120° from the vertical, shown in Fig 5, with a limiting speed of more than 60,000 rpm. This was explained by assuming that he sum of the weight vector at zero degrees and the hydrostatic vector at 120° added vectorally to a radial load of one-g, displaced to 60° from the vertical. This means that the direction of radial acceleration force must be known before you can place the asymmetrical slots in the right position. Such design, however, would still be limited to zero-g operation at sea level, and certain limited accelerations normal to the shaft axis.

Developing the hybrid gas bearing

A more practical approach is to develop a method for hydrostatic pressurization at multiple points similar to the use of multiple Rayleigh steps in a hydrodynamic bearing. The hydrostatic pressurization is also necessary when the ambient pressure is low as in closed cycle turbo machinery.

To test this hypothesis the graphite shaft with C_d = 0.0027 in. was modified to provide 3, and 6 hydrostatic ports (0.020 in. dia) centered around each bearing land. Results with zero-g operation, are shown in Fig. 6. The cross plot in Fig 7 shows minimum flow (heavy dash lines) required for stable operation.

In the design operating speed range of 48,000 rpm, there is no significant difference in minimum required flow between 3- and 6-hole configurations. The configuration selected depends primarily on the source of lubricant supply pressure.

The load-carrying ability attained by a typical bearing with parameters derived from these tests is shown in Fig 8. These data were obtained at 47,000-rpm with radial loads from 3 to 18 lb and with hydrostatic pressure from 185 psig to 0 psig (hydrodynamic). At higher hydrostatic pressures, the load is supported directly in line with load application. As hydrostatic pressure is lowered, approaching hydrodynamic operation, the attitude angle increases towards 90°, consistent with the hydrodynamic theory.

These data are not yet complete enough to provide a check on calculated film thickness and attitude angles. The laboratory technique is, however, sufficiently advanced to make this verification at a latter date.

EDITOR'S NOTE: For other recent articles containing information useful in gas-bearing design, see:

How to Design Hydrodynamic Gas Bearings, Nov 25 '57, p 103—New equations and design charts make an easy 6-step-procedure for selecting the proper design parameters.

For the complete text of eight earlier articles presenting design considerations in the selection and application of ball and roller bearings, order a copy of the new 64-page combined reprint "Rolling Element Bearings" from Reader Service Dept, Product Engineering, 330 W 42nd St, NY 36. Price $2.

—Frederick Marich

specifying an elastomer for the first time?

THESE 10 GUIDEPOSTS TO LOW-COST RUBBER PARTS

To suit your need, the rubber being "milled" in the photo above may require several dozen constituents. This means you must be clear about the kind of product you want, or costs will mount. Following these 10 basic rules will save you time, as well as money.

C H YATES, *manager*
Product Engineering Dept
R B BOND, *assistant chief compounder*
Firestone Rubber & Latex Products Div
Firestone Tire & Rubber Co
Fall River, Mass

In order to obtain reliable rubber parts at a reasonable cost and with a minimum of problems, there are several basic rules to be followed:

1. Order by specification when possible

By far the great majority of rubber products fall into the same range of requirements. Most of the rubber items made today can be made from a relatively limited number of compounds and these can be easily designated by ordering to specification such as ASTM-SAE D735. There are other specifications which follow this same general method of designating compounds. In addition, there are many government specifications which may provide just the qualities needed for a particular application. The tabulation on p 62 lists the most commonly used rubber specifications.

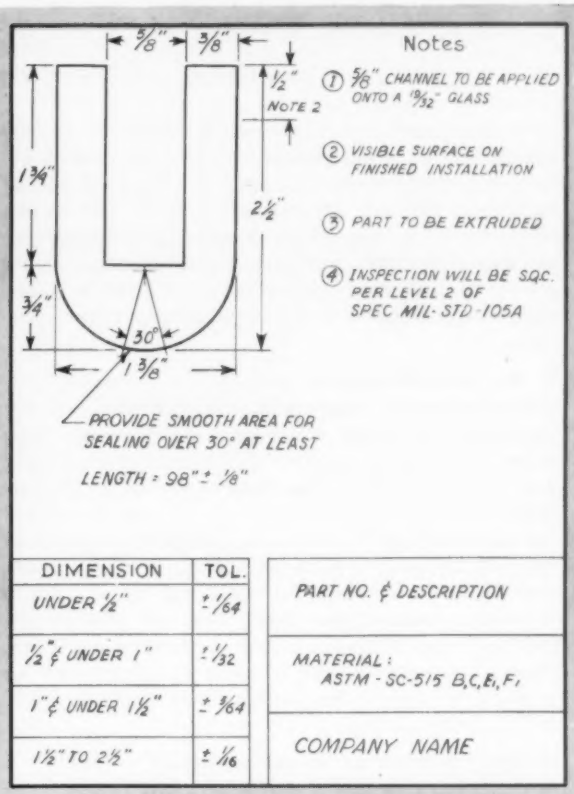
Arriving at the proper designation is not as difficult as it first appears. First study the part in its application and determine the conditions to which it is exposed. What temperature ranges must it endure? Will it be exposed to any fluids? What kind? Will the weather be a problem? Having analyzed the application, you can then determine what specification designation best approaches these conditions. It may take some time to master the designator system built into a given specifica-

This Rubber-part Drawing Is Complete

The drawing shown here contains all information the rubber compounder and fabricator needs to estimate costs accurately and produce parts that will perform satisfactorily. Included are: complete material specifications, tolerances required on all dimensions, application and appearance information, quality level, proposed methods of fabrication, and notation of critical areas. Material designator SC-515 B, C, E_1, F_1 based on ASTM-D 735; SAE standard 10R. Meaning of the various designator components for this material is given in the accompanying table. Components designating other requirements will be found in D 735.

BREAKDOWN OF RUBBER DESIGNATOR SC-515 B, C, E_1, F_1

Designator	Description	Must meet ASTM test
SC	Neoprene	
5	Durometer hardness (50 ± 5)	D 676
15	Tensile strength (1500 psi)	D 412
B	Compression set	D 395
C	Weather resistance	D 1171
E_1	Oil resistance (ASTM oil No. 1	D 471
F_1	Low-temperature brittleness (at −40 F)	D 1053



tion; however, experience has shown this to be time well spent.

The effects on rubber which must be considered can be divided into seven broad categories. All of these must be considered when designating a rubber compound, and any good specification will take all or most of them into account (see example above).

Physical distortion: Elasticity is the rubber's primary function; ability to recover from any distortion is its main reason for being. Tension, compression, torsion and flexing are the influences to be considered. The more severe the conditions, the higher the grade of rubber needed and, of course, the higher the cost.

Fluids: Exposure to oils, solvents or chemicals determines the type of rubber used. The application should be examined to ascertain what liquids contact the part and to what degree. Is the exposure casual or is it a case of continuous total immersion?

Temperature: Here you must determine the maximum and minimum temperatures to which the rubber will be exposed. Again, is the exposure continuous or intermittent? Resistance to extremes of temperature will determine both the type of rubber and the way in which it is compounded.

The elements: Effects of sunlight, ozone and the weather can be disastrous unless they are prevented by proper compounding and choice of polymer. Most rubber compounds contain normal amounts of sunlight and ozone preventives, but these are not sufficient where extreme or long-term exposures are anticipated.

Staining and discoloration: In cases where rubber is used in contact with paints, enamels, plastics, and fabrics, special care must be taken to make sure the chemicals in the rubber do not migrate from the rubber to the adjacent material and develop stains. Colored compounds can normally be made so that they do not vary on exposure to light.

Physiological effects: Where rubber items are to be used in contact with the body (for example: grips, seats, inhalators, earphones, etc.) special care must be taken to be sure that no toxic or irritating constituents are included. At the same time, odor and taste in the rubber must be kept to a minimum.

Electrical properties: Electrical insulation is one of the more common uses of rubber products. Special compounding is necessary to ensure the highest resistance to electrical breakthrough or the lowest degree of energy absorption. At the other extreme are rubbers which actually conduct electricity. These are used where static sparks may constitute a hazard, such as in operating rooms or other areas where solvent or gas fumes may occur.

2. Be prepared to compromise on properties

There is no way to compound a rubber item to get all the maximum qualities in the one stock. For instance,

in natural rubber, formulas which have the highest possible degree of heat resistance will stain, tensiles will be lower, and odor will be a problem. Hard compounds will not have high ultimate elongations, and so on. Therefore, it is important to know what properties are considered of prime importance and what properties are secondary. There are savings to be realized by eliminating requirements which have no relation to the application.

3. Do not over-specify

It is a normal reaction, when not familiar with the capabilities of rubber, to call for specifications far in excess of their actual needs. This can be very expensive and can often lead to unnecessary problems of development.

Over-specifying usually means asking for a high tensile strength. Rubber, except for thread or rubber bands, is seldom used in tension so that a high tensile strength is relatively meaningless. Most items are used in compression, where compression-set is the important property. Low-cost compounds with excellent compression set are available, so that by designating a high tensile you have really asked for a high price.

4. Don't depend on sample-matching

Often you may have a rubber item that is performing satisfactorily. If you are not familiar with rubber specification and requirements, and are searching for a new source, it is a temptation to submit a sample of the present material for matching. These samples are usually small, sometimes no bigger than a postage stamp. To get an ordinary tensile and elongation requires a strip 1 in. x 6 in.; thus it is evident that the rubber supplier can do little more than guess at the properties of the material. Here, a large enough sample must be provided to allow complete testing.

The rubber chemist can also determine only so much from a sample. Further, running all the possible tests is very expensive and can take months. An idea of the conditions of use must also be supplied to prevent the chemist from overlooking some obscure need in the final product.

5. Allow the supplier enough time

This applies when a new rubber compound must be developed for the job. The development of a new compound is largely trial and error, based on the compounder's experience and knowledge. Trial batches must be mixed, test pieces must be cured and these pieces tested. If no sample passes, the process is repeated until the proper formula is obtained. This process can take considerable time, depending on the type and complexity of the new requirements and on the experience of the rubber chemist.

6. Locate parting lines correctly

On molded items, it is very important that the permissible positions for parting lines be shown on the cross-sectional drawing. Often there are areas on the part where design will not permit a parting line–a sealing surface, for example. Yet the area where a parting line cannot be allowed might be the ideal place for the rubber-engineer to part his mold. Such critical areas should always be noted on the drawing. If this problem cannot be avoided, the type of seal and the allowable finish of the part itself should be clearly spelled out.

On extruded items, noting critical areas is also very important because it may be that a multicavity extruding die can be used. Here, it may be necessary to join the cavities by means of a fine line, which will then appear on the final product. This extrusion-die parting line should be located away from critical surfaces of the extrusion.

7. Specify the quality level desired

Overlooking this factor is a common fault on 99% of the product drawings for rubber parts. Quality standards or the inspection levels to be applied to the product are all too often overlooked at the design stage. If the part is to be inspected under Statistical Quality Control (SQC), the level and the sampling plan should be spelled out. If mass inspection is acceptable, this should also be shown and the corresponding quality level considered.

TYPICAL RUBBER SPECIFICATIONS

ASTM	D-735	Elastomer compounds for automotive applications
	D-1330	Sheet rubber packing
	D-69	Friction tape
	D-119	Rubber insulating tape
Military	MIL-R-880A	Rubber, med soft (for airport, airtight and watertight door and hatch gaskets)
	MIL-R-900	Rubber sheets, and cut, molded and extruded special shaped sections, synthetic, med soft, low temperature
	MIL-R-2765	Rubber material, synthetic, oil resistant (sheet, strip and molded shapes)
	MIL-R-3065	Rubber fabricated parts
	MIL-R-6855	Rubber, synthetic, sheets, molded and extruded, for aircraft applications
	MIL-R-7362	Rubber, sheet, solid, molded and extruded shapes, synthetic oil resistant
	MIL-R-15624	Rubber sheets, and cut, molded and extruded, special shaped sections—shipboard gasket except low temperature application
	MIL-P-1384	Packing, synthetic rubber, cloth insertion

Performance tests, if any, should be spelled out, including the type of test equipment to be used. Refer to commercial standard tests wherever possible. Testing by the customer and supplier should be performed on the same type of equipment. These steps will lead to lower, more accurate costs and will prevent disputes between supplier and customer.

All such "quality level" factors should be displayed prominantly on the product drawing. Then, careful attention to them will make for smooth transition from drawing to delivery on a production basis in a minimum of time.

8. Pay attention to tolerances

A product drawing is never complete unless the tolerances are completely spelled out. Give tolerances for each and every dimension if few dimensions are involved; or if the part is complicated, it can be done by means of a simple allowable-tolerance table on the drawing itself.

The basic trouble with rubber-product drawings today is that most of them show steel-product tolerances. Wider tolerances will decrease cost; design in $\frac{1}{64}$'s where possible, instead of in thousandths.

The Rubber Manufacturers Association specifies tolerances for various types of rubber products for various methods of manufacture. You should become familiar with their publications. Tolerances specified on a product drawing have a great bearing on how the product will be made. Very tight tolerances on a molded item will reduce the number of cavities per mold, thus increasing the total mold cost or slowing production. On extruded items where tolerances are fairly liberal, multi-cavity dies can be used and costs reduced in this way.

9. Start with a careful product-drawing

There are many instances in the rubber industry today where parts are made based on samples—a very dangerous practice if the item involved is to have critical dimensions. The submitted sample may well be on the high side or low side of acceptable tolerance, and the rubber-engineer will not be aware of this if no product drawing is submitted with the sample part. The first step should therefore be the product drawing—agreed upon between you and the supplier before molds are made or production begins.

10. Consider how the part will be made

Many rubber items can be made a number of ways and you can often choose the most economical one. Most extruded items can be made molded—barring, of course, length limitations. But on extruded items, it is impossible to hold close tolerances and finish that can be held on a molded item. However, the extruded cost for the part is much less than would be the molded cost for the same part. In addition, extrusion dies cost substantially less than the molding tools.

Some parts can be made extruded and then butt-spliced, thereby eliminating the need for a completely molded item. However, butt-spliced extruded items do have limited strength at the splice. Or take another example: A number of flat, narrow and thin extruded parts can also be made by calendering (i.e. rolling). Again, a comparision of cost, finish, and tolerance for both processes must be made by consulting the rubber supplier or fabricator.

EDITOR'S NOTE: See next week's issue (Apr 17) for a comprehensive selection guide to high-damping materials for vibration control. Other recent articles covering elastomeric materials and fabrication techniques include:

7 Reliability Tests for Synthetic-rubber Coated Diaphragms, Jan 30 '61, p 38—Describes a series of tests for final screening of coated fabrics once the main candidates have been selected.

How to Select the Right Gasket Material, Oct 3 '60, p 52—This 4-step procedure puts design emphasis where it belongs, on the total bolt force applied to the joint at installation.

Damping Tapes for Vibration Control, Jan 25 '60, p 57—Author describes a cheap, reliable, and lightweight way to dissipate excess vibratory energy—keeping resonance stresses low and cutting fatigue failure.

Short-run Blanking by the Rubber-Die Process, Jan 25 '60, p 57—An economical method for thin sheetmetal fabrication, that will handle runs of up to 500 parts—or models for development work.

New Foamed Silicones Give Hi-temp Insulation, Jan 5 '59, p 60—Article gives design data on the latest rigid, semirigid and flexible self-curing silicones. Basic library of plastics articles also included.

Coatings and Fabrics for Today's Diaphragms, Oct 26 '59, p 68—You have to know all the types or you'll be designing diaphragms that don't meet today's needs. Here, selection charts guide you to the right base fabric and rubber coating.

Comparison of Rubber Properties, Mid-Sep '59, p 112—Physical properties of elastomers can be varied by compounding; hardness, resilience, compressibility can be changed, permitting different applications for the same basic compound. Article compares 10 elastomers.

Today's Rules for Rubber-to-metal Bonding, Aug 3 '59, p 52—Nearly any rubber can be bonded to almost any rubber, using established techniques plus modern adhesives. Article reports on how to obtain reliable bonds and desired tolerances.

Best Recipe for Casting Urethane Foam, Nov 10 '58, p 86—Urethane elastomers also have a "rigid" twin brother suitable for many structural applications requiring light weight. Article reviews technology and design procedures.

The Latest on Silicone Rubber Sponge, Aug 4 '58, p 54—Now, with better sponging grades, sharper process controls, and special reinforcing techniques—tolerances can be predicted and rejects decreased.

Faster Molding of Rubber Parts, June 23 '58, p 68—New molding techniques gives rubber parts high dimensional accuracy and low-cost availability. Article shows how to design for the process.

Molded Silicone Rubber Parts, Apr 14 '58, p 69—The same product that thrives on abuse at high temperature may be a weakling during installation. Here are tips on curing methods, shape of parts, and other variables that determine satisfactory service.

High-temperature Butyl Rubber, Nov 11, '57, p 90—Improvements in butyl rubber now provide an economical solution for difficult flexibility problems at temperatures above 350 F. Data compares HTB with five similar elastomers.

Cast Urethane Rubber, Sep 16 '57, p 68—Article presents basic property data and design procedures for this abrasion-resistant elastomer developed in Germany, now being applied here.

Gasketed Joints for Electrical Equipment, Mar '57, p 183—Article presents design criteria, characteristics of ideal material, 8 common types, 18 basic joint designs.

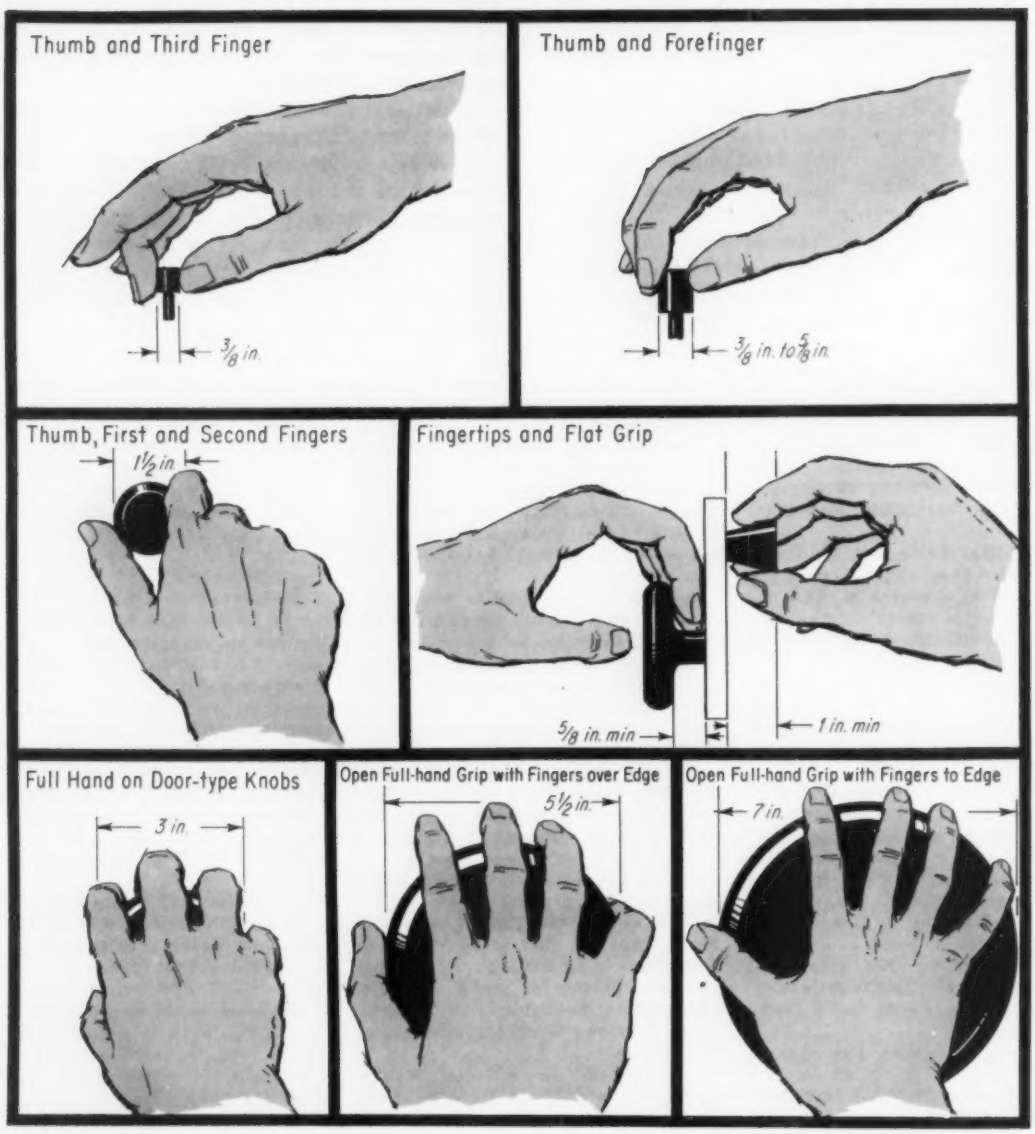
—Ford Park

DIMENSIONS for HAND GRIPS

To get maximum advantage from knobs and handles, use the size suggested in these sketches.

FRANK WILLIAM WOOD JR
President, Advanced Designs Inc
Vienna, Va

KNOBS



HANDLES

Four Fingers
3 1/4 in.
Two Fingers
1 5/8 in.
Ring
2 3/4 in. min dia
For 1 finger use: 1 in. dia min
For 2 fingers: 1 1/2 in. dia min
For 3 fingers: 2 1/4 in. dia min
T-Bar
3 in. min
1 in.
Pole
1 3/4 in.
Recessed Pull
1/2 in.
1/2 in. radius
5/8 in.

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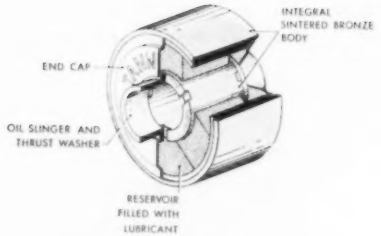

Journal bearing . . .
with permanent lubrication is less expensive than, and interchangeable with, general-purpose ball bearing in rotating-shaft applications. Said to run quieter than medium-price ball bearing and to be highly resistant to humid or abrasive environments. One-piece, sintered-bronze combination bearing and housing has self-wicking lubricant packed in space between members. Designed for light to moderate loads at moderate speeds, it has derated PV value of 25,000 and operates in range of −25 to 200 F. Not recommended for stationary-shaft applications, since centrifugal force may force oil through sealed outer face. Available in 13 sizes from ¼-in. ID and ¾-in. OD to 20-mm ID and 47-mm OD. Priced at approx 25¢ depending upon design requirements. **Tann Bearing Co, Div of Tann Corp, 3750 E Outer Dr, Detroit 34.**

Circle 300 on Reader Service Card

Self-bonding silicone rubber
can be joined to ferrous metals without priming and is said to offer adhesive force stronger than highest strength silicone rubber. Material is slowly ruptured when stretched to five times its original size, but bond remains intact. Establishes its bond through direct reaction with a metal surface. Supplied as a gray compound, it has following properties after 25-hr cure at 350 F: tensile strength, 1500 psi; tear, 200 psi; elongation, 550%; durometer, 50; and compression set 22/300 F, 45%. From stock at $5.20 per lb in 1000-lb quantities. **General Electric Co, Silicone Products Dept, Waterford, NY.**

Circle 301 on Reader Service Card

18% nickel alloy steel . . .
is reported to have a yield strength of over 250,000 psi while maintaining ductile properties below −80 F. Developed by International Nickel Co Inc, the alloy is a martensite, iron-nickel, which is aged. In addition to 18% nickel, it contains 7% cobalt, 5% molybdenum, less than 0.5% titanium and a max of 0.05% carbon. Notched tensile strength is said to exceed 400,000 psi (measured under severe conditions with notch radius of 0.0005 in.), and tests have shown that the material is suitable for high stresses and sudden shocks because it resists notching or cracking. Higher and lower tensile strength can be obtained by modifying basic composition (indications are that levels of up to 500,000 psi or higher can be achieved). Low work-hardening tendencies permit ease of cold-forming and shaping, while machining characteristics are said to be tops both as rolled and as fully hardened. Crack-free welds can be produced, even on material in fully heat-treated condition, without preheating. Available on request in all mill shapes and in all standard sizes, with prices reportedly ranging about three times higher than stainless steel. Delivery in 6 to 8 wk on some large orders; other deliveries defined by demand. **Allegheny Ludlum Steel Corp, 2020 Oliver Bldg, Pittsburgh 22.**

Circle 302 on Reader Service Card

Heavy-duty transmission . . .
has electromagnetic clutches that provide speed changes and reversing under power without stopping motor. Available in two, three or four speed changes with max reduction of 10:1 and is suitable where hp's of 40 to 150 are required. Clutch capacity is 3060 lb-ft (runing). Remote control of speed changes can be accomplished with electric switches, tape, cam or other automatic controls. Supplied for horizontal or vertical mounting, unit measures 34 x 22 x 20½ in. and weighs approx 600 lb. Shaft diameters: input, 2.125 in.; output, 3 in. Priced from $2,000 to $4,500, depending on number of speed changes and over-all reduction. Delivery in 10 to 12 wk. **Western Mfg Co, 3428 Scotten Ave, Detroit 10.**

Circle 303 on Reader Service Card

Centrifugally cast tubes . . .
made of fiberglass-reinforced polyester or epoxy, are available in lengths up to 93 in., in any wall thickness, and in OD measurements of 10, 12¾ and 15 in. Ceramic, plastic or metal inserts and closures can be integrally molded in the tubes at any location or can be added after casting. Bonds are said to be strong and permanent (bonds to aluminum develop over 2500 psi tensile shear). Internal surfaces of as-cast tubes have density comparable to that of magnesium. Retain elasticity until loaded to ultimate strength, show no long-term creep or load hysteresis, and resist most chemicals except concentrated acids and alkalis. Temperature limits range from extremely low to over 300 F. Tubing only (not including inserts, ribs, etc.) is priced from 50¢ to $1.50 per lb. Delivery in 2 to 4 wk on 10-in. dia tubing. **Clevite Ordnance, Div of Clevite Corp, 540 E 105th St, Cleveland 8.**

Circle 304 on Reader Service Card

Limit switch with neon light
has indicating lamp built in. Light is normally on when switch is not in operation; goes off when switch arm is actuated. Lamp insert can be installed in switch cover to make contact with either normally open or normally closed contacts.

continued on page 68

Switch is rated at 10 amp, ½ hp at 120 v ac and has two-circuit, double-break contact arrangement. Aluminum housing has four tapped holes for ¼ through 20 UNC screws or #10 clear bolts for mounting. For conduit connection, there is a ½ through 14 NPT threaded opening. From stock at $20 each. **Micro Switch Div, Minneapolis-Honeywell Regulator Co, Freeport, Ill.**

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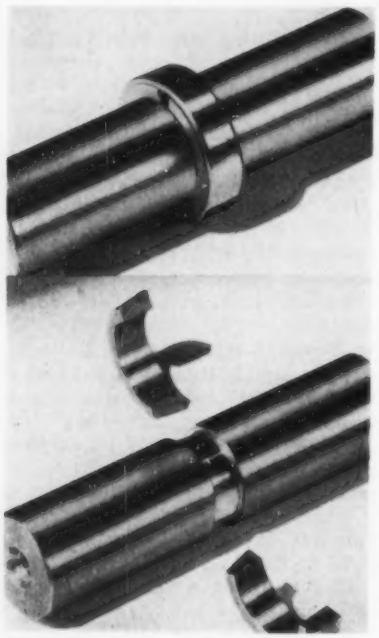

Shaft collar . . .

combines conical-shape split inner ring and locking retainer ring. Withstands high thrust loads in one or both directions and provides accurate location for shaft-mounted parts. Split inner ring taper locks into shaft, eliminating turned shoulders. Suitable for connecting air or hydraulic cylinder shafts to other members in high-thrust load applications, collars are available in sizes up to 4 in. dia and in external or internal types. **Bearing Accessories Co, 7320 Lake Shore Blvd, Mentor, Ohio.**

Circle 306 on Reader Service Card

Neoprene contact adhesive . . .

bonds supported vinyl fabrics to metal, wood and composition bases; thin gage metals or foils to wood, cement asbestos board, hard board and composition bases; and fabric-backed urethane sheets to metal, wood and composition bases. Material—a yellow, air-drying solvent adhesive with synthetic rubber base—has consistency of thin syrup and can be applied by brush, spray or roller coater. Reportedly has high peel strength; permanent strength and resilience; and good water and fatigue resistance. Available in ½-pt cans, 48 to the carton; 1-pt, 1-qt and 1-gal cans; 5-gal pails; and 55-gal drums. **Armstrong Cork Co, Industrial Div, Lancaster, Penna.**

Circle 307 on Reader Service Card

Teflon seal ring . . .

has resilient X-shape cross-section which permits installation with either slight or moderate seal contact pressure or interference. Does not have to be stretched as much as a Teflon O-ring during installation because lips are designed to flex. Efficiency of cup-type seal increases with pressure. Its temperature limits are —300 to 500 F. When service requires resistance to heavy wear or extreme temperature variation, seals are available in a reinforced Teflon that has about half the thermal expansion of regular Teflon. Supplied in 126 standard O-ring sizes with 0.114 to 4.475 in. ID's. Smallest size seals are priced from $23 to $42 per 100 and largest size, from $252 to $432 per 100, depending upon quantity. Delivery in approx 3 wk on standard sizes. **Allegheny Plastics Inc, 25 Thorn Run Rd, Coraopolis, Penna.**

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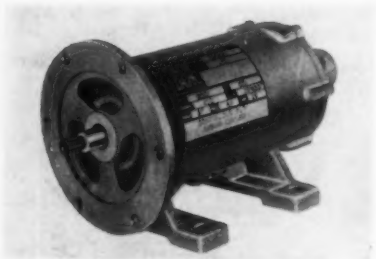

Pump drive motor . . .

has vapor-phase cooling system that is said to prevent viscous and churning losses, and make internal seals unnecessary. Elimination of rotating seals between pump and motor reportedly increases system reliability. Motor, a 400-c, 200-v, 3-phase unit, produces 6 hp at 11,600 rpm and operates at 80% efficiency. Portion of the system fluid is bled from pump output and conducted through motor. From stock in 2 and 6-hp sizes with flange or foot mounting. **Task Corp, 1009 E Vermont Ave, Anaheim, Calif.**

Circle 309 on Reader Service Card

Hi-temp ceramic adhesive . . .

bonds at up to 2600 F after being cured at only 250 F. Has low dielectric constant and loss tangent, attains high degree of mechanical strength and does not flake or disintegrate during use. The paste-like consistency adhesive also can be used for coating items requiring high-temperature protection. Bonding two 0.3 x 0.4 x 0.9 in. pieces of ceramic dielectric, adhesive shows following properties at 77 F: perpendicular to the bond, a dielectric constant of 2.12 and a loss tangent of 0.0348; parallel to the bond, dielectric constant of 1.85 and loss tangent of 0.0092. **Special Products Div, Melpar Inc, 3000 Arlington Blvd, Falls Church, Va.**

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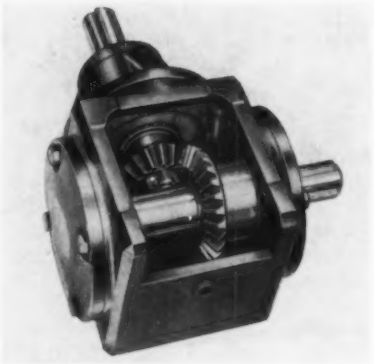


Gearbox . . .

transmits up to 45 hp. Steel-cut gears on ground shafts of stressproof steel turn on roller bearings. Input rotation can be either clockwise or counter-clockwise. Ratios available include reverse and 1:1, 1.5:1 and 2:1. Max and standard shaft size is 1¼ in. **Von Ruden Mfg Co, Claremont, Minn.**

Circle 311 on Reader Service Card

Hi-temp polypropylene . . .

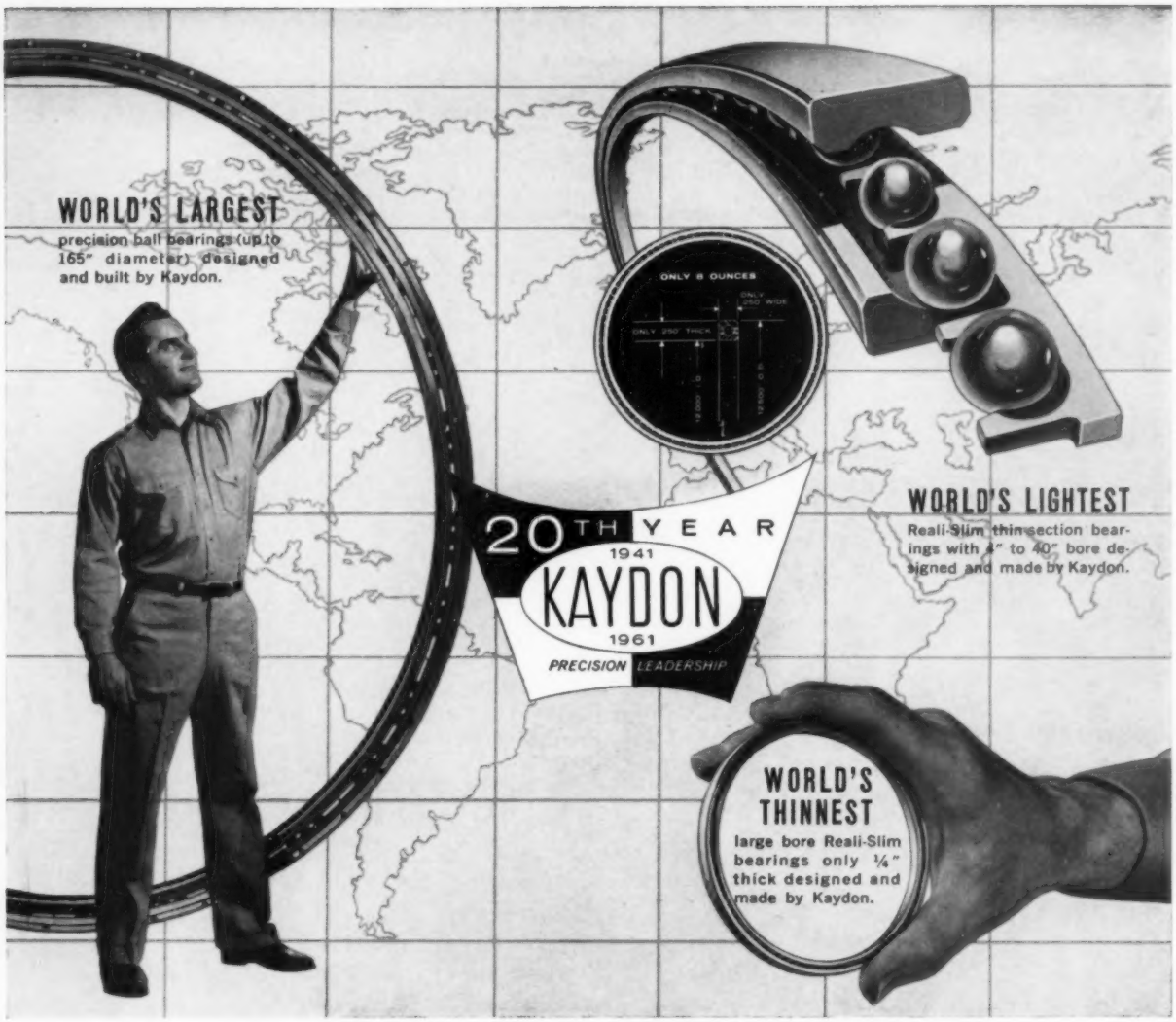
suitable for molded parts subject to repetitive, long-term heat exposure, melts at 335 F and has melt index of 5.5 at 230 F. Test specimens reportedly have withstood more than three months oxidative aging at 300 F. At 250 F, specimens show no evidence of failure after more than six months. Available in natural color, or a variety of colors on request. Supplied in 50-lb bags at 46¢ per lb in 20,000-lb lots. **Enjay Chemical Co, Div of Humble Oil & Refining Co, 15 W 51st St, New York 19.**

Circle 312 on Reader Service Card

Dual valve-assembly interlock

for protection of air-actuated clutches, is designed so that if one valve remains open when deenergized, the other valve will close and stop the machine. Before another stroke or cycle can be started, defective valve must be repaired or replaced. Assembly meets JIC specifications and is an integral part of clutch-control circuit. Includes two 3-way valves connected in

continued on page 70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Standard bearings often aren't adequate when you run up against a combination of limitations involving bearing capacity, size, weight, configuration, material and price.

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Available! Reali-Slim type "CP" bearings off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new one-piece snapover bronze separator in 4" to 12" bore — ¼" to 1" width and cross section.

K-611

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All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

World's highest capacity, lowest cost needle bearings (22 sizes available).

series; two limit switches actuated by poppet extensions of the valves; and a wiring enclosure housing a terminal strip. From stock at $198.65 with ¾-in. valves and at $227.65 with ¾-in. valves. **Micro Switch Div, Minneapolis-Honeywell Regulator Co, Freeport, Ill.**

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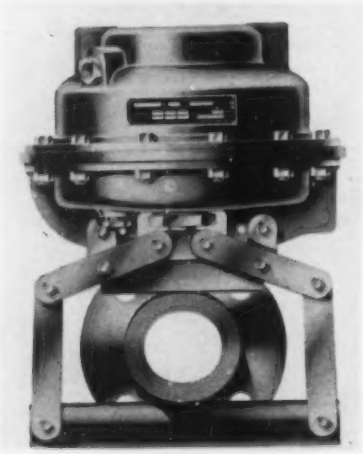

Automatic flexible valve . . .

controls highly abrasive slurries and corrosive materials in locations too hazardous or inaccessible for manually operated valves. Has pipe-like body which provides unobstructed flow. Closes bubble tight even on small solids. Absorbs vibration, is unaffected by water hammer and reportedly outlasts metal valves 11 to 1. Available in wide range of body materials, including pure gum rubber, Buna-S, Buna-N, Neoprene and Butyl or compounds of each. Sizes range from 1 to 12 in. Connections include slip-on and flanged types. **Farris Flexible Valve Corp, 705 Commercial Ave, Palisades Park, NJ.**

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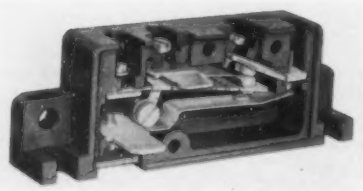
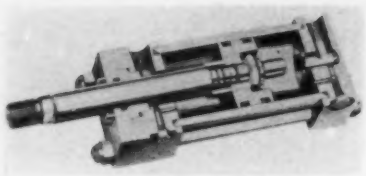


Thermal time-delay relays . . .

are available with SPST-NC or NO contacts, two independent circuits or SPDT. Rated 100 milliamp to 10 amp, up to 115 v ac, they have totally enclosed bakelite housings and terminals to accept either solder or standard quick connect wiring. Priced at 90¢ each in quantities of 100. **E-T-A Products Co, 6285 N Cicero Ave, Chicago 46.**

Circle 315 on Reader Service Card



Low-pressure cylinders . . .

operating up to 1500 psi, range in size from 1½ to 6-in. dia bores. Have steel barrels for added rigidity, and close-fitting iron pistons for longer bearing areas. Seal arrangements automatically lubricate bearings at all times. **Milwaukee Cylinder Co, Cudahy, Wis.**

Circle 316 on Reader Service Card

Magnetic pickup . . .

converts motion into pulses without contact, using a dc magnetizing coil and separate output coil. By removing the dc when no output is required, no magnetic force coupling exists between pickup and moving element. When dc coil is energized, voltage appears across output coil proportional to speed of magnetic material across pickup probe. Output can be regulated by varying dc excitation. From stock at $30. **Kinelogic Corp, 1256 N Fair Oaks Ave, Pasadena, Calif.**

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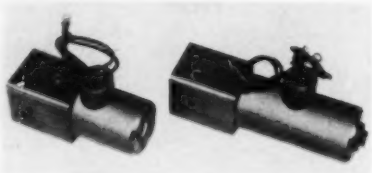

Miniature directional valves

are available as 4-way valves in both single and double solenoid models. Rated to 1000 psi with max capacity of 2 gpm (nominal capacity of 1½ gpm), they are suitable for small volume systems used in jig positioning and clamping; hydraulic gear shifting and clutching on machine tools; and venting on hydraulic system relief valves. Ac and dc solenoids with low current consumption are supplied in all standard voltages. Include alternate ⅛-in. pipe thread cylinder port connections located opposite mounting faces which contain four normal port openings. **Vickers Inc, Div of Sperry Rand Corp, Detroit 32.**

Circle 318 on Reader Service Card

Fiberglass extruded shapes

for structural, electrical and heat barrier uses, are available with unidirectional or omnidirectional reenforcing fibers, in a wide selection of resins, fibers and fillers. Continuous process extrudes intricate shapes in sizes ranging from $\frac{3}{64}$ to approx 6 in. in dia. Lengths are limited only by shipping restrictions. **New Plastic Corp, 1026 N Sycamore Ave, Los Angeles 38.**

Circle 319 on Reader Service Card

Weldable strain gage . . .

can be attached to almost all aluminum alloys with an 80-w-sec capacitor discharge welder, using RWMA electrodes in the handpiece. Operates at temperatures equal to deterioration point of aluminum (750 F for short periods acceptable). Nominal gage factor is 1.75. Both 60- and 120-ohm gages are available, measuring $\frac{3}{16}$ in. wide and either $1\frac{3}{32}$ or $\frac{7}{16}$ in. long. All types can be inherently temperature compensated for aluminum alloys. **Microdot Inc, 220 Pasadena Ave, South Pasadena, Calif.**

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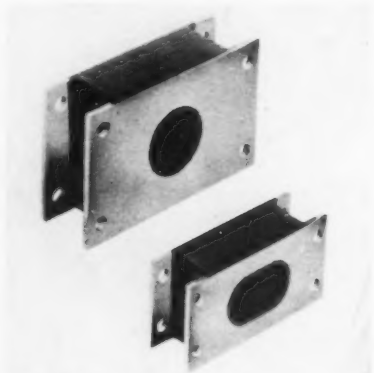


Elastomeric shock mounts . . .

have ±10% spring rate and are bolted with no studs required. Two standard sizes have two configurations each. Dimensions of smaller series are 3 x 6 x 1¾ in. Their spring rates range from 630 to 1500 lb/in. and from 450 to 1000 lb/in. Load ranges are from 567 to 1650 lb and from 450 to 1100 lb at 1-in. deflection. Larger amounts measure 5 x 8 x 2⅜ in. and have spring rates from 1000 to 3000 lb/in. and from 820 to 2000 lb/in.; load ranges from 900 to 3300 lb and from 743 to 2200 lb at 1-in. deflection. From stock. **Lyon Aircraft Services, 2701 N Ontario St, Burbank, Calif.**

Circle 321 on Reader Service Card

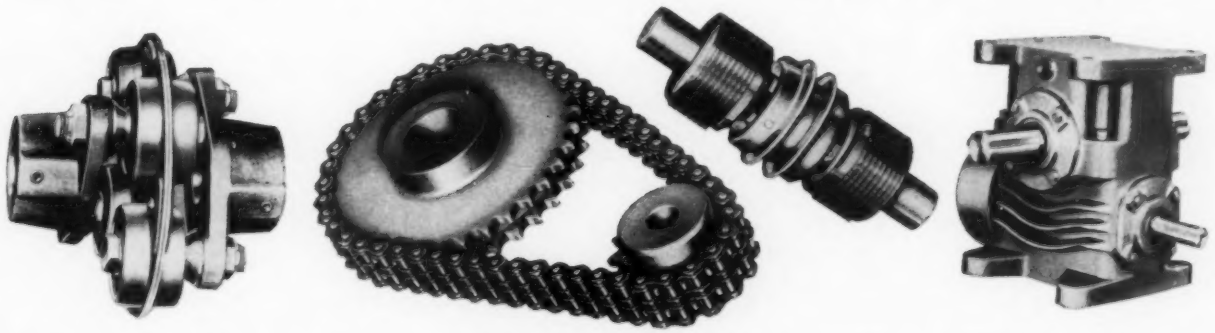
High-pressure solenoid valve

uses from 1 to 3 w power and serves under pressures up to 200 psi in temperatures from −65 to 350 F. Operates in any position with max rate of 1000 cpm at 100 psi. Weighing only 5 oz, it is available in 6 to 64 v dc; 6, 12, 24 and 110-220 v, 60 c ac; and 110 v, 400 c ac models. Inlet connection is ¼-in. NPT and outlet connection, ⅛-in. NPT. Over-all length is 2⅝ in., with dia of 1⅛ in. Positive close-off

continued on page 72

Morse has an answer to every industrial drive problem under the sun

Basic Drives, Speed Reducers, Couplings, Clutches—only Morse makes all four and only Morse stocks all four. For example, if your industrial drive problem involves basic drives such as roller chain, silent chain, and Hy-Vo® Drives, or "Timing"® belts, friction clutches, and couplings, too, look to Morse for the answer. You'll get impartial engineering help and immediate delivery.



As for quality, Morse products speak for themselves: Morse timing chain is original equipment in over 76% of American cars. So whatever your industrial drive problem, see your Morse man. He's in the Yellow Pages. Or write: Morse Chain Co., Dept. 4-41, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

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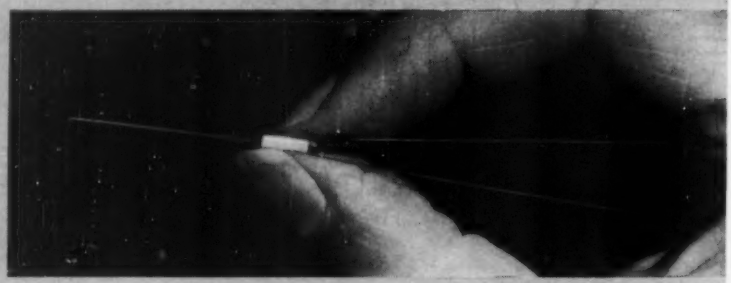
CIRCLE 71 ON READER SERVICE CARD

BLH DEVELOPS WORLD'S SMALLEST FULLY INSULATED TEMPERATURE SENSOR ...HT MICRO-MINIATURE THERMOCOUPLE



Response time is reduced significantly by these new fully insulated, electrically fused wire element thermocouples. A typical time constant is 1.2 milliseconds with an exposed junction design immersed in stagnant oil.

Unique construction permits the entire probe and leads to withstand temperatures of the hot junction, which may be (1) exposed, (2) sealed and insulated, or (3) grounded and flattened. All configurations are designed for minimum disturbance of environment.

⅓ the size of a human hair...the sensing element wires are insulated with pure fused ceramic that does not pick up moisture from the air and has a voltage breakdown of 10,000 volts at room temperature. The probe is .014 in. dia., and the lead wires are .010 in. dia. for easy handling.

Cryogenic to 3000°F temperature range makes the HT Micro-Miniature Thermocouple ideal for measuring temperatures of rocket fuels, missile and aircraft skins, jet engine exhausts, atomic piles, and various testing and process operations throughout industry.

Nationally available through 16 BLH sales engineering representatives throughout the U.S. and Canada, these temperature sensors are manufactured by BLH under exclusive license of High Temperature Instruments Corp.

Write us...or contact your nearest BLH representative for a copy of our 6-page product data folder.

BALDWIN • LIMA • HAMILTON
Electronics & Instrumentation Division
Waltham 54, Mass.

BLH — FIRST in force measurement

SR-4® Strain Gages • Transducers • Temperature Sensors • Systems

at any pressure is provided by self-aligning synthetic rubber needle valve. Standard lead lengths up to 24 in. are available with valve. **General Magnetics Inc**, 2641 S Louisiana Ave, Minneapolis 26.

Circle 322 on Reader Service Card

Compact relay . . .

is said to save up to 50% in control-panel space. Measuring 3⅛ in. high and 1⅛ in. wide, unit is available in any combination of normally open or normally closed contacts, from two to eight poles with a max of four normally closed. Rated full load current is 6 amp at 300 v ac; operating time on pickup, 12.5 to 18 millisec; and on dropout, 6.25 to 12.5 millisec. Can be butted without need for additional insulation or electrical clearances. Clamp type terminals accept solid or stranded wire, sizes #14 through #18. Other design features: specially hardened magnet and armature pole faces; very short operating stroke; silver alloy contacts that have slight wiping action when mating; and kickout springs for positive action in opening, independent of gravity. **Westinghouse Electric Corp**, PO Box 2099, Pittsburgh 30.

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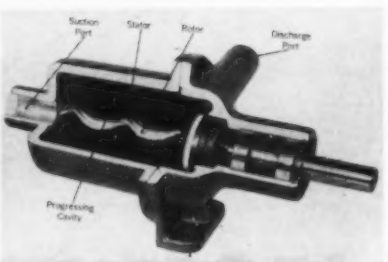

Low-capacity pumps . . .

for domestic and commercial appliances, use "progressing cavity" principle to handle almost any type of material from water-like liquids to abrasive slurries, including solids in suspension. As stainless steel rotor turns within synthetic rubber stator, pockets are formed between two elements

RULON® AND TEFLON*

Self-Lubricating RULON Puts Wear-Free Care-Free Performance Into Your Designs

More and more designers rely on RULON bearings to take high loads and speeds, extreme temperature ranges, corrosive conditions . . . to insure greater service life . . . and to cut costly maintenance.

Because of its low coefficient of friction, Dixon's RULON (reinforced TFE) keeps frictional heat down, guarantees low starting torque and smooth vibration-free performance. RULON parts are *reinforced* to resist wear and deformation under load. Also chemically inert, RULON won't swell in the presence of liquids . . . keeps its mechanical properties over −400°F to +500°F range. And because RULON parts can run *completely dry*, they contribute vital performance advantages where designs call for inaccessible or lube-free radial, thrust, or reciprocating bearings.

You'll solve a lot of problems when you look at your designs with RULON in mind . . . stamped, postformed, machined or molded parts . . . specially reinforced fluorocarbons for special applications. Also a wide variety of basic shapes in RULON or Teflon. Write for Brochure #9572, or look up our catalog in Sweet's Product Design File. DIXON CORPORATION, 103 BURNSIDE STREET, BRISTOL, R. I.

* DuPont T.M.

DIXON

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that move toward discharge port. Pumping action is said to be turbulence-free with positive displacement and continuous, uniform flow. Smallest model has capacities of from 1.8 gph at 30 psi to 3.75 gph at zero pressures when operated at 850 rpm. At 1700 rpm, capacities go from 4.5 to 7.5 gph over same pressure range. Five larger models operate at either 1750 or 3600 rpm. Lower speed capacities climb from 6 gph at 40 psi to 240 gph at 10 psi, while higher speed ratings go from 18 to 360 gph in 40 to 10-psi range. Can be either belt driven or direct connected. **Moyno Pump Div, Robbins & Myers Inc, Springfield, Ohio.**

Circle 324 on Reader Service Card

Stainless cushion clamps . . .

resist temperatures of up to 1500 F. Made of type 321 stainless steel, they are available in sizes from ¼ to 4-in. ID and are interchangeable with standard ½-in. AN, MS or commercial type cushioned loop clamps. Cushion is corrugated to furnish spring action for high-frequency, low-amplitude vibration. Has flat surfaces for max tube contact and dissipates heat by using convection, conduction and radiation. Cushioning is spot welded to clamp and edges are crimped for abrasion-free grip. **TA Mfg Co, 4607 Alger St, Los Angeles 39.**

Circle 325 on Reader Service Card

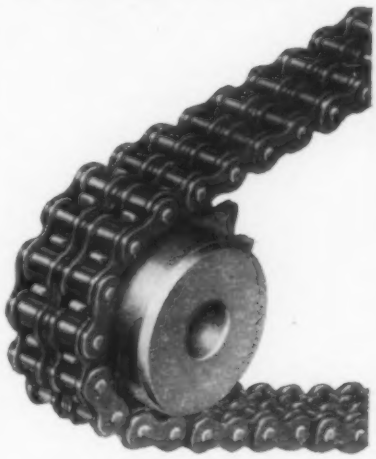
Electromagnetic brake . . .

for fractional-hp motors and gear trains, brakes when deenergized and releases when energized. Applies a braking force in event of a power failure and has optional manual release when that type of operation is required. User can preset torque at which brake will slip. Standard voltages are 6, 12, 28, 48 and 100 v dc. Two sizes are available: One with $1\frac{7}{64}$-in. body dia and $1\frac{5}{8}$-in. mounting flange dia has braking torque of 10 in.-oz min and is rated at 2 w power input; another with $1\frac{9}{16}$-in. body dia and mounting flange die of $2\frac{1}{4}$ in. has braking torque of 30 in.-oz min and is rated at $3\frac{1}{2}$ w power input. Former is priced at $49; latter, $52. Prototypes from stock. **Dial Products Co, 19 Cottage St, Bayonne, NJ.**

Circle 326 on Reader Service Card

continued on page 75

A Morse answer



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...when the problem involves service life and performance

Superior fatigue resistance

Increased horsepower ratings

Statistical hardness control

Electronically controlled pitch

All parts automatically inspected

Drive-design service

Distributor-stocked

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Morse Chain Co., Dept. 4-41, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

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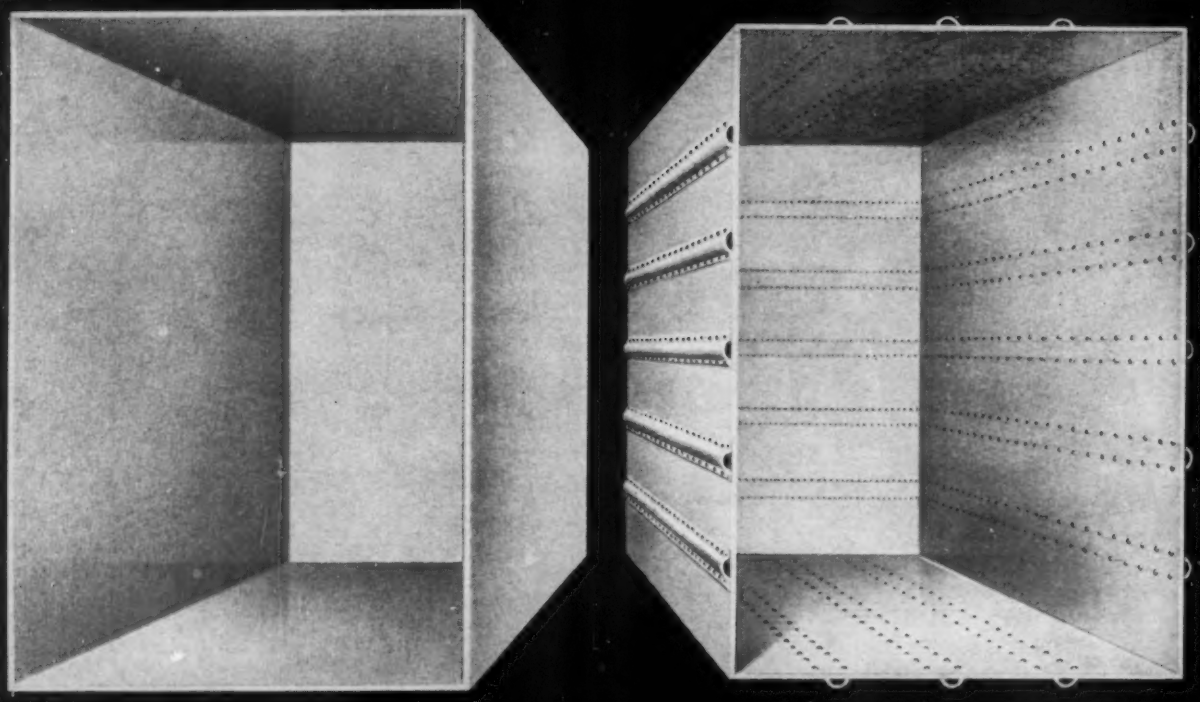


NO-RIB RIBBED

Thick-gauge magnesium sheet is so rigid that time-consuming rib stiffeners and fasteners are eliminated. Yet the magnesium panels are light and strong, resist dents and punctures better than thin-skinned ribbed construction.

WHICH HIGH-STRENGTH DESIGN WEIGHS LESS... COSTS LESS TO BUILD?

Magnesium no-rib, of course. By increasing the sheet thickness slightly, designers of containers and vehicle bodies get a tremendous boost in rigidity, thus can eliminate stiffening ribs. And since magnesium is the lightest structural metal, the resulting unit weighs less than conventionally-designed structures using other metals. (No-rib design in other metals introduces a severe weight penalty.) Magnesium no-rib structures are smooth-walled, minimize crevices for water seepage, have greater cubic capacity pound-for-pound than ribbed units. For detailed information on using magnesium no-rib construction for fabricated units of all types, write THE DOW METAL PRODUCTS COMPANY, Merchandising Department 1108DZ4-10, Midland, Michigan.

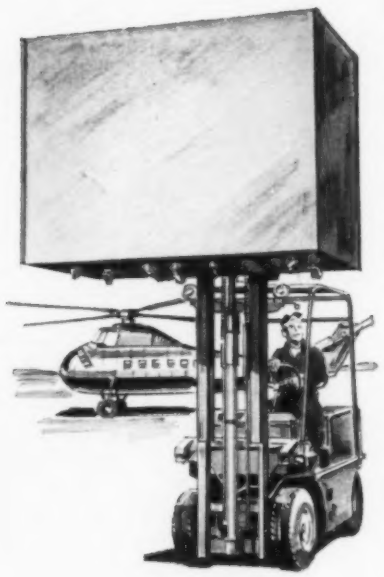
DOW THE DOW METAL PRODUCTS COMPANY

Division of The Dow Chemical Company

CIRCLE 74 ON READER SERVICE CARD

DOW

HOW MAGNESIUM NO-RIB DESIGN CUTS CONTAINER COSTS AND WEIGHT



Cargo containers can be made both strong and light . . . and at less cost . . . with magnesium no-rib design. Fabricated from stiff sheets of lightweight magnesium, container walls need no stiffening ribs or supports.

No-rib design eliminates costly, time-consuming installation of ribs and fasteners . . . provides strong, dent-resistant walls that are smooth inside and out . . . produces economical containers that, pound-for-pound, have greater cubic capacity than ribbed containers of any other metal.

Dow magnesium sheet alloy ZE10A is ideal for no-rib construction. It provides high welded-joint strength and *needs no stress relief* after welding. For equipment handling and cargo containers, storage bins, vehicle bodies, magnesium no-rib construction offers maximum strength at lightest weight . . . and savings in construction time and costs!

DOW

THE DOW METAL PRODUCTS COMPANY
Division of The Dow Chemical Company
Midland, Michigan

Rectangular panel meters . . . are of all-metal construction with steel movement enclosures that protect against effects of magnetic panel materials or stray frequencies. Scale length of 4 x 6-in. gasket-sealed units is 4.7 in. for max visibility and reading ease. Standard finish is flat black, but bezel can be provided in any color. **Helipot Div, Beckman Instruments Inc, 2500 Fullerton Rd, Fullerton, Calif.**

Circle 327 on Reader Service Card

Magnetic-reed switch . . . is a sub-miniature dry reed unit with gold plated contacts, hermetically sealed in an inert atmosphere. Contact reeds are slightly offset from leads to allow full surface contact when closed. Rated at 12 v-amp max, resistive up to ½ amp, up to 250 v ac, switch has contact resistance of 40 to 60 milliohm, plus 40-milliohm lead resistance. Life expectancy is said to be over 5 million operations at full rating; considerably more at lesser loads. Arrangements can be normally open, normally closed with bias magnet, and latching. Over-all length, including 0.002-in. dia leads, is 1½ in. **Hamlin Inc, Lake & Grove Sts, Lake Mills, Wis.**

Circle 328 on Reader Service Card

Low-speed generator . . . delivers 0.5 kva, 3 phase, 60 c at 1200 rpm, compared with its former rating of 0.25 kva. Power output has been increased while size and weight remains same—6½ x 10½ x 9 in., weighing 50 lb in welded steel construction. **Georator Corp, Manassas, Va.**

Circle 329 on Reader Service Card

Digital voltohmmeter . . . is high-input-impedance device with following full scale ranges: 1, 10, 100 and 1000 v dc; 100, 1000, 10,000, 100,000 ohm; and 1 and 10 megohm. Accuracy is 1% on dc v ranges and 2% on ohm ranges (except 10 m range which is 5%). Transistor-equipped, chopper-stabilized dc amplifier eliminates need for zero or calibrate adjustments in order to make meas-

A Morse answer

Morflex couplings

...when the problem involves vibration and misalignment

Isolate vibration

Cushion shock

Absorb misalignment

Torsionally flexible

Impervious to water, dirt, oil

Arrest electrolysis

Distributor-stocked

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urements. Circuitry is protected so that up to 5000 v across meter terminals on any voltage range does not damage instrument. Takes up 3½ x 8½ in. of panel space and 6 in. depth. Power consumption is 22 w at 115 v, 60 cps ac. Available in either rack mounted or bench models at $295. **Cofax Electronics Corp, 537 Commerce St, Franklin Lakes, NJ.**

Circle 330 on Reader Service Card

Silicone-rubber tape . . .

has tensile strength of 70 lb-in. width and when vulcanized, bonds to a homogeneous mass with top electrical properties and moisture resistance. Made of 2 mil glass cloth with 3 mils of unvulcanized silicone rubber calendered on one size, tape can be used as a heater element blanket; for wire and motor coil wrapping; and for ducting and other electrical applications requiring strong, thin, abrasion resistant wrap. **Permacel, New Brunswick, NJ.**

Circle 331 on Reader Service Card

Precision wire-wound potentiometer . . .

is a linear translatory unit, providing an output voltage proportional to shaft displacement. Produces resolution of 0.1% full scale and linearity of 0.2% full scale throughout 250,000 operating cycles. Meets 28 g rms white noise requirements. All components are enclosed in one-piece aluminum housing which is O-ring sealed. Delivery in 30 to 45 days at price said to be lower than conventional model. **Lido Transducers, 1970 Placentia, Costa Mesa, Calif.**

Circle 332 on Reader Service Card

Toggle switches . . .

reportedly have no contact bounce, tracking or false signals. Operate in −60 to 250 F range for at least 10 million cycles. Available in four contact arrangements—SPST, SPDT, DPST and DPDT. Contact rating is 10 amp at 250 v ac. From stock. **Elotect Corp, 1425 N Lidcombe, El Monte, Calif.**

Circle 333 on Reader Service Card

Teflon-lined rubber tubes . . .

are unaffected by commercial chemicals, withstand continuous 200 F for several months without cracking and have dielectric strength of 500 to 2000 v/mil. Combination of Teflon and Neoprene keeps liners round, protects them from abrasion and provides thermal insulation. Liner is available in ⅛- through 1-in. ID sizes covered with ⅛-in. Neoprene rubber or other elastomers, in specified lengths. **Pennsylvania Fluorocarbon Co Inc, 1115 N 38th St, Philadelphia 4.**

Circle 334 on Reader Service Card

continued on page 77

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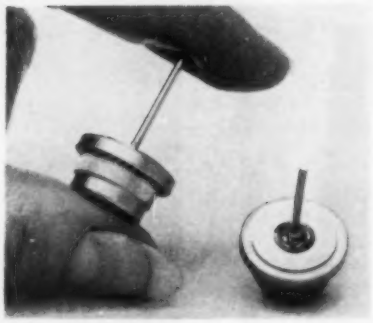
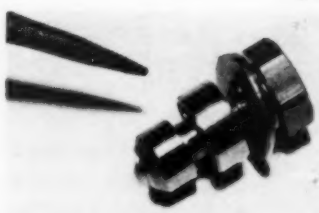


18-amp rectifier . . . reduced in price to 58¢ each in quantities of 10,000, is expected to create new circuit design possibilities for shop equipment, speed controls, portable mixers, dc power supplies, ignition systems, flashers, chargers, etc. Rated for operation at case temperatures of —67 to 347 F, unit is housed in a welded, hermetically-sealed, $\frac{5}{8}$-in. dia knurled case with $\frac{11}{16}$-in. long axial-lead top terminal and is designed for press-fitted mounting into a heat sink. **Motorola Semiconductor Products Inc, 5005 E McDowell Rd, Phoenix, Ariz.**

Circle 335 on Reader Service Card



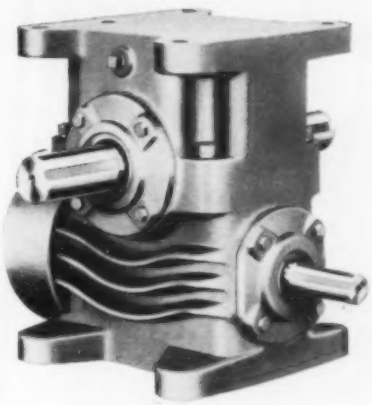
Precision cam-followers . . . range in ODs from $\frac{1}{4}$ to $\frac{3}{8}$ in. for use in close-quarter timing applications. Available in face widths from 0.1406 to 0.1960, units have shielded ABEC 7 tolerance ball bearings fitted on concentric ground shafts for full-contact tracking and smooth operation. From stock at $3.95 to $4.40 each, complete with spacers, lock washers and hex nuts. **PIC Design Corp, 477 Atlantic Ave, East Rockaway, LI, NY.**

Circle 336 on Reader Service Card

Battery substitute . . . for laboratory potentiometers, operates from line voltage and delivers a constant dc voltage to measuring circuit bridge. The 117-v ac supply is reduced by a step-down transformer and converted to dc by rectifying with silicon diodes. Dc voltage is regulated by a two-stage zener diode network. Voltage stability is ±0.01% or less for line voltage variations of ±10%. Priced at $95. **Dynage Inc, 75 Laurel St, Hartford, Conn.**

Circle 337 on Reader Service Card

A Morse answer



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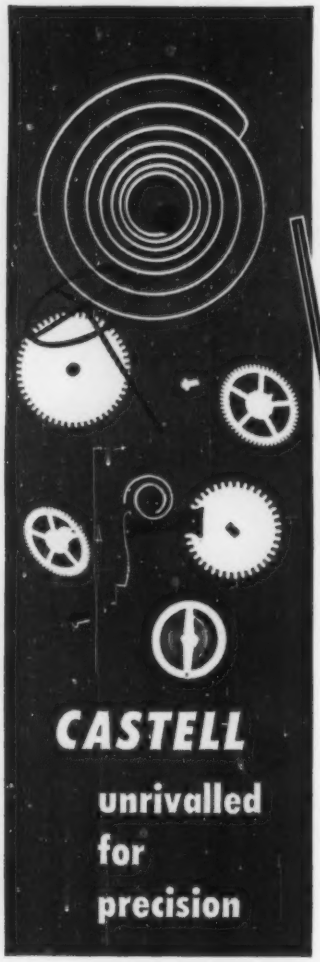

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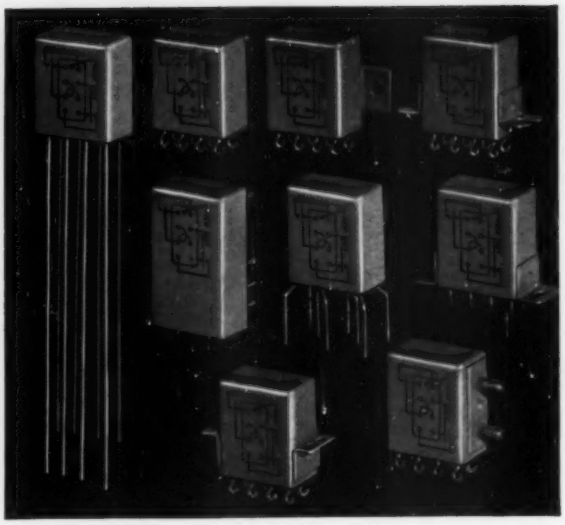

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despite extreme temperatures,
heavy shock, severe vibration

CLARE Type F
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DESIGN LITERATURE

Staff in Organization

ERNEST DALE, L F URWICK. McGraw-Hill Book Co Inc, 330 W 42nd St, NY. 8⅓ x 5½, 241 pp. $6.

As a department or an organization grows in size, it is likely to find that its subdivisions become overburdened with problems in planning, controlling and coordinating their various functions. This book suggests an organizational device that is often misunderstood by companies and even by organizational specialists: the use of general staff men. The general staff man, one of whose titles usually is "assistant-to," is widely employed in industry today, but because there is so much misunderstanding of his functions and status, he is often less valuable than he might be, and is sometimes a disruptive force in the organization.

To ascertain when and how an executive can utilize the device of the general staff, this book explores what executives do in their working time (one of the authors actually sat in the offices of chief executives for days on end). It examines the various types of staff found in industry today and their relationship to the line; analyzes the theory and use of staff in military organizations, which encountered the problem of large-scale organization earlier than industry did, and explains how military practice must be modified for industrial use. It discusses the use of general staff men by US Presidents, and shows what business can learn from White House experience.

Actual case histories of successful and unsuccessful assistants-to—with analyses of the reasons for success or failure—provide guides for executives who are using or planning to use general staff men, for organizational specialists, and for men who hold the position or aspire to it.

Kinematics and Linkage Design

ALLEN S HALL JR. Prentice-Hall Inc, Englewood Cliffs, NJ. 7 x 9¾, 162 pp. $8.50.

Kinematics is a broad and highly technical subject, and the problem every author faces is how to make a comprehensive presentation in a compact form. This book does it by emphasizing basic ideas without attempting to present all possible ramifications and details. Understanding of the fundamental ideas of linkage design is stressed rather than the mere solving of numerous problems.

The aim here is to give a broad coverage which can be useful to graduate students and others who need an introduction as well as the highlights of kinematic design. The basic kinematic and geometric ideas presented have wide application, as is brought out in some problems.

Its best features are a selected number (73) of worked-out design problems, and its summation of data from widely scattered sources. This includes material from foreign-language books which has been brought together here for the first time. Its emphasis on dimensional synthesis of linkages is more thorough than one would expect in such a compact volume.

Transistors—Principles, Design, and Applications

WOLFGANG W GARTNER. D. Van Nostrand Company Inc, 120 Alexander St, Princeton, NJ. 9¼ x 6¼, 675 pp. $12.50.

For serious students and practicing engineers. This book devotes four chapters to semiconductor theory, then describes construction of transistors. The meat of the book—the last 12 chapters—explains and gives circuit-design details on each important application for transistors. A few are: dc bias supplies, amplifiers, oscillators, printed circuits, and circuit applications exploiting nonlinearities in transistor characteristics.

Other Books of Interest

Mathematics, Queen and Servant of Science

E T Bell. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 5½ x 8, 437 pp. $2.50.

Revised and amplified version of two formerly published accounts of mathematics by the same author.

Introduction to the Statistical Dynamics of Automatic Control Systems

V V Solodovnikov. Dover Publications Inc, 180 Varick St, NY 14. 5¼ x 8, 305 pp. $2.25.

Logic Machines and Diagrams

Martin Gardner. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 5¼ x 8. 157 pp. $2.25.

continued on page 81

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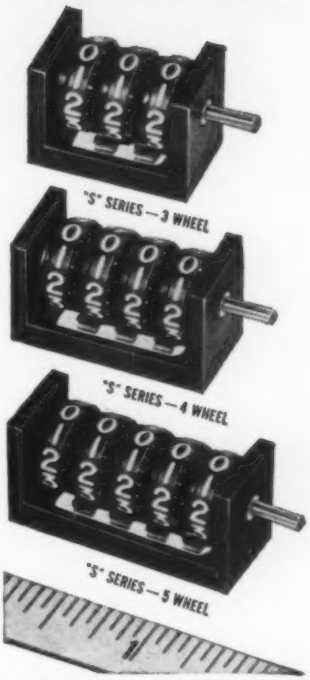

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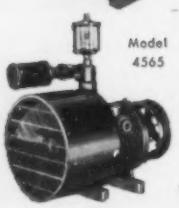

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0465	4.0	25	30	½	18
0765	5.9	10	15	½	18
1065	8.3	25	30	1	33
2065	17.0	15	20	1½	52
2565	21.0	15	20	2	51
4565	45.0	15	20	5	92

*Without base or electric motor.

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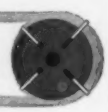

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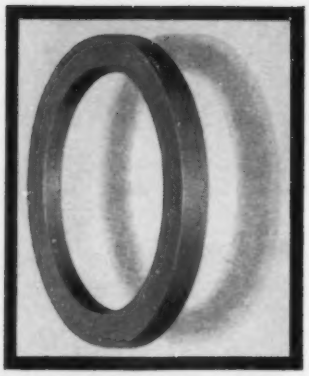

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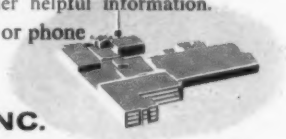

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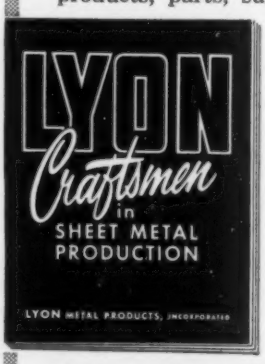

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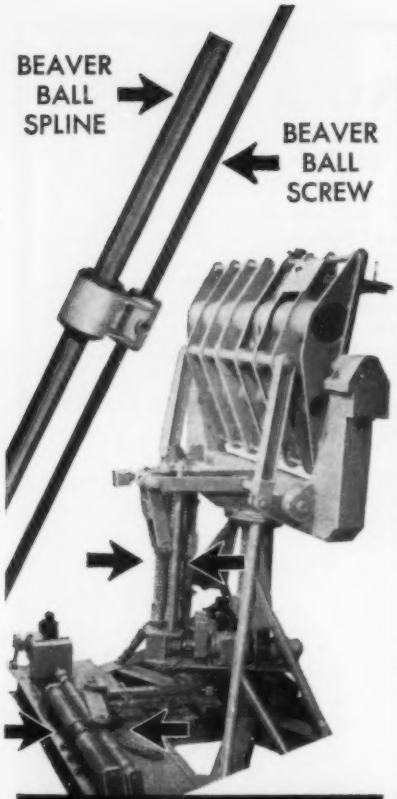

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An Engineering Approach to Gyroscopic Instruments

E J Siff, C L Emmerich. Robert Speller & Sons, Publishers Inc, 33 W 42nd St, NY 36. 6¼ x 9¼, 120 pp. $7.50.

The Fermi Surface

W A Harrison, M B Webb, Editors. John Wiley & Sons Inc, 440 Park Avenue South, NY 16. 8¾ x 11¼, 356 pp. $10.

Contains proceedings of international conference on Fermi surfaces of metals and summarizes progress of last few years in understanding electronic properties of metals.

ABSTRACTS FROM THE LITERATURE

Learned in the Test Lab

Environmental test laboratories, both independent and in-company, accumulate a lot of data and experience of value to equipment designers. Yet objectivity that is demanded of them may be compromised if they offer design advice. This article attempts to communicate some of the more widely applicable lessons learned, particularly with respect to vibration, shock and acceleration, temperature, humidity, altitude.

"Designing for Qualification," William Tankowich, Associated Testing Laboratories, Inc. Environmental Quarterly, Jan '61, 252-46 Leeds Road, Little Neck 62, NY.

Strength of Polymers

The Griffith theory for brittle fracture predicts that the tensile strength should be inversely proportional to the square root of the size of a defect or flaw in the sample tested. The validity of this relation has been investigated for the glassy polymers,

continued on page 83

". . . a miniature rocket . . . about so big. Have you seen one?"

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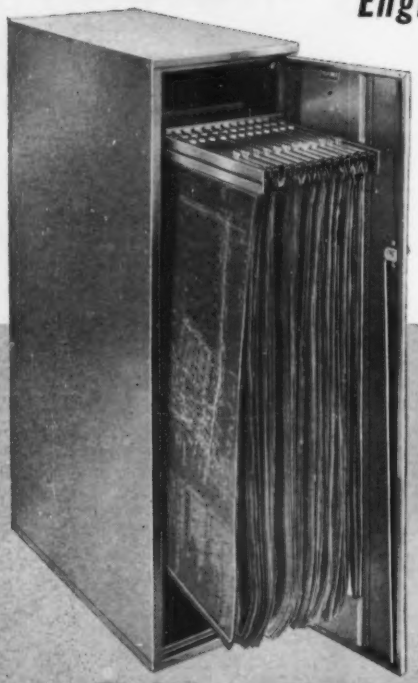

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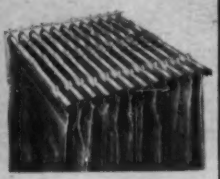

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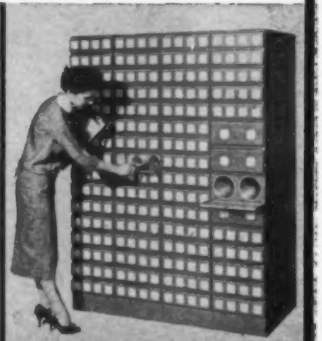

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methyl methacrylate and for polystyrene. The results indicate that the strength of the polymers depends on two factors; the surface energy, and the inherent flaw size. The surface energy is primarily that dissipated in a viscous-flow process and the inherent flaw size is related to the tendency of the polymer to craze under stress.

"The Strength of Glassy Polymers," by J. P. Berry, General Electric Research Laboratory. Presented at 17th Annual Technical Conference, SPE, 65 Prospect St, Stamford, Conn.

Expansion-joint Behavior

Describes factors affecting design of expansion joints for piping systems. Both slip type and packless or bellows type joints are discussed. Formula evolved from analysis of single corrugation of bellows design is included.

"Evaluation of Expansion Joint Behavior," Alexander Samoiloff, Badger Mfg Co. Power, Jan '61, 330 W 42nd St, New York 36.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

POWER TRANSMISSION EQUIPMENT—Catalog GC-101-F, 24 pp. Lists sizes of several thousand stock parts, including split taper bushings, sheaves, pulleys, belts, sprockets, chains, couplings, bearings, hubs, etc. Typical parts are pictured. Browning Mfg Co, Maysville, Ky.

Circle 350 on Reader Service Card

STAINLESS STEEL TUBING—Catalog, 20 pp. Covers sizes, grades and types and provides data on chemical requirements and analysis. Also contains price chart, basic requirements, price references and sample computations. Sumitomo Shoji New York Inc, Tubular Products Div, 149 Broadway, New York 16.

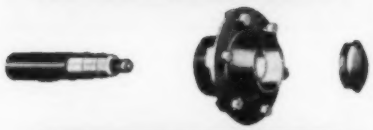
Circle 351 on Reader Service Card

IN-LINE READOUTS—Brochure, 16 pp. Compares major types, including electroluminescent, projected-image, spherical-optic, indicator-tube, edge-lighted and electromechanical displays. Discusses and charts their readability, life, size, weight, drive requirements, cost, power, etc. Burroughs Corp, Electronic Tube Div, Dept LR-5, PO Box 1226, Plainfield, NJ.

Circle 352 on Reader Service Card

EXPLOSIONPROOF CONDULETS—Bulletin 2722, 60 pp. Quotes National

continued on page 85



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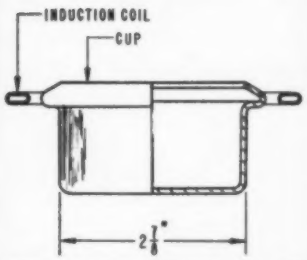

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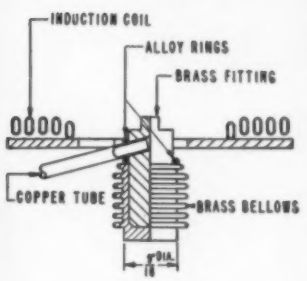

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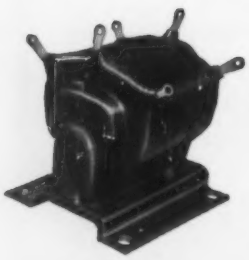

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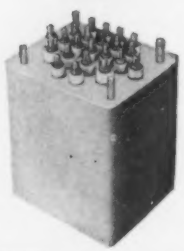

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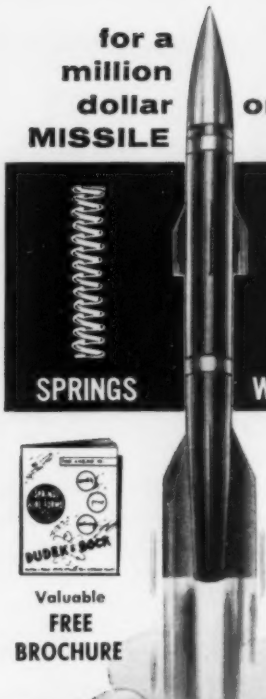

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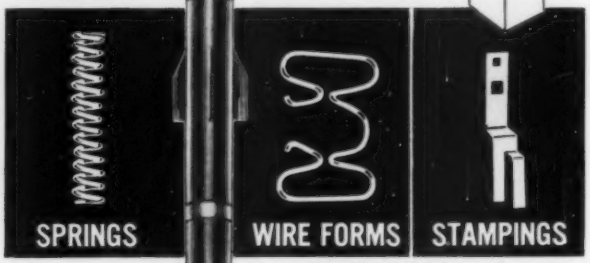

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Electrical Code articles and details applications of condulets in hazardous locations. Includes product photographs and installation diagrams. Crouse-Hinds Co, Syracuse 1, NY.

Circle 353 on Reader Service Card

METAL-LIKE ACETAL RESIN—Booklet, 24 pp. Outlines properties of the thermoplastic engineering material—a highly crystaline, stable form of polymerized formaldehyde. Also covers fabricating techniques, coloring, painting and design development and gives case histories of the material at work in variety of products and industries. EI du Pont de Nemours & Co, Polychemicals Dept, 13000 W Seven Mile Rd, Detroit 35.

Circle 354 on Reader Service Card

CAST-TO-SHAPE STEELS—File folder, approx 9 pp. Supplies chemical composition and heat-treating instructions on five grades, and explains company's facilities to produce castings through conventional sand-casting, shell-molding or ceramic-molding processes. Vanadium-Alloys Steel Co, Latrobe, Penna.

Circle 355 on Reader Service Card

LOCKNUT INSTALLATION—Manual 6101, 18 pp. Contains 12 tables listing recommended installation torque values for thin and standard height hex-type nuts. Discusses factors to be considered in selecting a tightening torque and effects of lubricants. Includes tables of tensile-stress areas and bolt strengths. Elastic Stop Nut Corp of America, 2330 Vauxhall Rd, Union, NJ.

Circle 356 on Reader Service Card

FLOW PROBES—Catalog 61, 40 pp. Describes and gives specifications of flow probes, thermocouples and positioners for measuring velocity, temperature and flow direction of gases and liquids. Includes flow equations, analysis of errors and typical instrument layouts for testing fluid-flow equipment. United Sensor & Control Corp, Glastonbury, Conn.

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STAMPED GEARS—Catalog 6011, 16 pp. Tabulates specifications of several hundred stamped gears, segments, internals, ring and crown gears, sprockets and ratchets made from stock dies. Also presents data on center hole shapes, tooth parts and diametral pitch rules and formulas for spur gears. Winzeler Mfg & Tool Co, 7355 W Wilson Ave, Chicago 31.

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NYLON STOCK SHAPES—Bulletin, 4 pp. Physical-property data and suggested applications are presented for new nylon

continued on page 86

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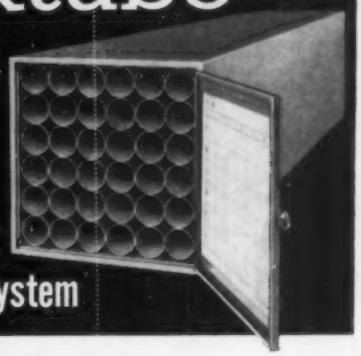

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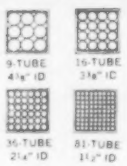

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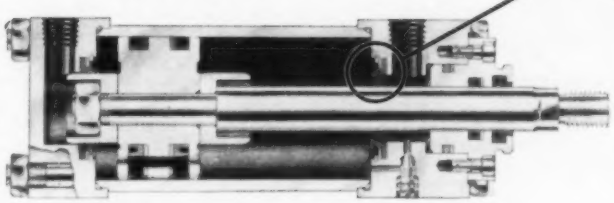

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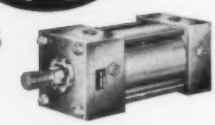

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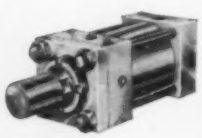

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SELF-LOCKING SWAGE NUT—Bulletin 2701, 4 pp. Performance data includes size-by-size tabulation of min tensile strengths in pounds for both coarse and fine threads, as well as push-out and torque-out values. Swaging principle and nut's three-point locking action are illustrated. Standard Pressed Steel Co, Box 545, Jenkintown, Penna.

Circle 360 on Reader Service Card

SILICON RECTIFIERS—Bulletin 300, approx 6 pp. Lists more than 350 types by their current ratings and supplies condensed electrical and mechanical specifications. Includes cutaways of double-diffused silicon disks, diodes and stacks as well as curves displaying forward current rating levels and derating for raised ambient temperatures. Semiconductor Div, Syntron Co, Homer City, Penna.

Circle 361 on Reader Service Card

LIQUID-BLENDING SYSTEMS—Bulletin 650, 8 pp. Explains advantages of line blending and illustrates operating principle of units which form primary components of a proportioning system. Schematics describe purpose and function of various secondary components from which packaged systems are engineered for specific job requirements. Blackmer Pump Co, Grand Rapids, Mich.

Circle 362 on Reader Service Card

FRACTIONAL-HP MOTORS—Bulletin PL-SB 2820, 6 pp. Tabulates specifications and prices of over 500 general and special purpose units, including jet pump, oil burner, belt drive furnace blower, air circulating and sump pump motors. Westinghouse Electric Corp, Industrial Motor Dept, Lima, Ohio.

Circle 363 on Reader Service Card

TEFLON TERMINALS—Catalog D2-1, 4 pp. Lists and illustrates dimensions of subminiature and miniature standoffs; subminiature and miniature feed-throughs; probes and plugs; and connectors and test jacks. Includes recommended installation hole data and list of insertion tools. Sealectro Corp, 610 Fayette Ave, Mamaroneck, NY.

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VACUUM METALLIZING—Brochure, 4 pp. Chart lines up surfaces and properties desired with recommended coating systems; coating and thinning methods; and system properties. Process and

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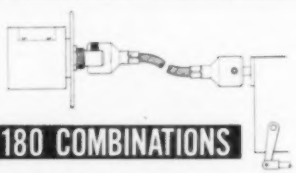

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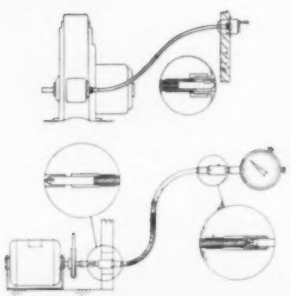

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methods of application are discussed. Bee Chemical Co, 2700 E 170th St, Lansing, Ill.

Circle 365 on Reader Service Card

SELF-LOCKING CAPSCREWS—Bulletin, 4 pp. Describes and illustrates design and locking principle and suggests applications. Klincher Kapscrew Inc, Dept KK1-227, 2153 Hillside Ave, Indianapolis 18.

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HOSE ASSEMBLIES—Bulletin IEB-53, 4 pp. Matches fitting and hose numbers with desired assembly combinations (male pipe to JIC swivel, etc.). Aeroquip Corp, Jackson, Mich.

Circle 367 on Reader Service Card

SELECTIVE PLATING—Bulletin SP 1003, 4 pp. Covers deposition rates, metal concentrations and recommended current densities for high-speed selective plating process. Discusses process and equipment needed and lists varied industrial uses. Selectrons Ltd, 520 5th Ave. New York 36.

Circle 368 on Reader Service Card

TIMING AND DATA HANDLING—Catalog 2, 4 pp. Contains specifications and prices of time code generators; timing system auxiliary equipment; search and control systems for magnetic tape transports; data handling equipment; and tape programmers, readers, and adapter sockets. Electronic Engineering Co of California, 1601 E Chestnut Ave, Santa Ana, Calif.

Circle 369 on Reader Service Card

SWITCHGEAR AND CONTROLS—Bulletin 1260, 4 pp. Discusses advantages of control center which combines generator control circuits and instrumentation with automatic transfer switch. Components are pictured. Lake Shore Electric Corp, 205 Willis St, Bedford, Ohio.

Circle 370 on Reader Service Card

LEAKPROOF PUMPS—Bulletin 1030-3, 2 pp. Carries specifications, design features and performance curve showing total head in ft. Chempump Div, Fostoria Corp, Huntingdon Valley, Penna.

Circle 371 on Reader Service Card

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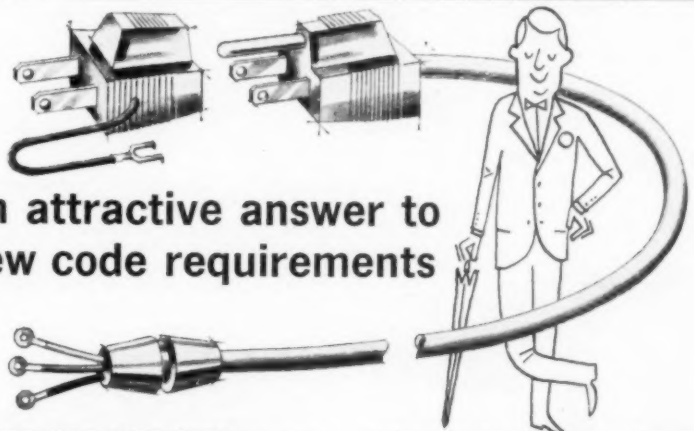

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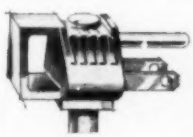

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INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

Acme Electric Corp. 84
Anchor Coupling Co., Inc. 28

Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div. 72
Bead Chain Mfg. Co. 82
Beaver Precision Products, Inc. 81

Clare & Co., C. P. 78
Clearprint Paper Co. .....3rd Cover
Country Engineering, Inc. 86

Dietzgen Co., Eugene 22
Dixon Corp. 73
Dow Corning Corp. 14
Dow Mental Products Co., Div., Dow Chemical Co. 74-75
Dudek & Bock Spring Mfg. Co. 84
du Pont de Nemours & Co., (Inc.), E. I., Film Dept. 40
Durant Mfg. Co. 79

Electric Wheel Co., Div. of Firestone Tire & Rubber Co. 83
Elliott Co. 26-27
Emcor-Ingersoll Products Div., Borg-Warner Corp. 76
Enjay Chemical Co., Div. of Humble Oil & Refining Co. ....4th Cover

Faber-Castell Pencil Co., Inc., A. W. . 78
Fairbanks Co. 84
Fulton Sylphon Div., Robertshaw-Fulton Controls Co. 31

Gast Mfg. Corp. 80
General Aniline & Film Corp., Ozalid Div. 29
Goshen Rubber Co., Inc. 80

Hitchiner Mfg. Co. 32
Hubbell, Inc., Harvey, Machine Screw Dept. 77
Hydreco Div., New York Air Brake Co. 7

I. B. M., Data Processing Dept. 5

Kaydon Engineering Corp. 69

Lamb Electric Co. 23
Lepel High Frequency Laboratories, Inc. 83
Lyon Metal Products, Inc. 80

Madison-Kipp Corp. 36
Marlow Pumps, Div. of Bell & Gossett Co. 33
Meyercord Co., Name Plate Div. 87
Miller Electric Co. 87
Minnesota Rubber Co. 2
Morse Chain Co., A Borg-Warner Industry 71, 73, 75, 77

National-Standard Co. 34-35
New Departure Div., General Motors Corp. 38
Newton-New Haven Co. 11
New York Air Brake Co., Hydreco Div. 7

Plan Hold Corp. 82

Robbins & Myers, Inc. 18-19
Rockford Clutch Div., Borg-Warner Corp. 37

S-P Mfg. Corp., A Bassett Co. 86
Saginaw Steering Gear Div., General Motors Corp. 10
Stacor Equipment Co. 85
Stephens-Adamson Mfg. Co., Spherco Bearings & Rod Ends Div. 88
Stewart Corp., F. W. 86

Tinnerman Products, Inc. .....2nd Cover

Vulcan Electric Co. 13

Waukesha Foundry Co. 30
Williams-Bowman Rubber Co. 85

Zierick Mfg. Corp. 82

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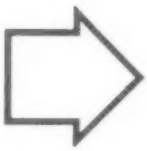

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2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

P76	P77	P78	P79	580	581	582	583	584	585	586	587	
588	589	590	591	592	593	594	595	596	597	598	599	

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NEW COMPONENTS

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NON-METALLIC MATERIALS, FINISHES
301—Self-bonding Silicone Rubber
312—Hi-temp Polypropylene
319—Fiberglass Extruded Shapes
331—Silicone Rubber Tape

POWER TRANSMISSION
303—Heavy-duty Transmission
311—Gear Box
313—Dual Valve Assembly Interlock
326—Electromagnetic Brake

MECHANICAL PARTS
300—Journal Bearing
304—Centrifugally-cast Tubes
306—Shaft Collar
308—Teflon Seal Ring
321—Elastomeric Shock Mounts
325—Stainless Cushion Clamps
336—Precision Cam Followers

FABRICATION PROCESSES AND PRODUCTION
365—Vacuum Metallizing, 4 pp, Bee Chemical Co.
368—Selective Plating, 4 pp, Selectrons Ltd.

POWER TRANSMISSION
350—Power Transmission Equipment, 24 pp, Browning Mfg Co.
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FASTENING AND JOINING
356—Locknut Installation, 18 pp, Elastic Stop Nut Corp of America
360—Self-Locking Swage Nut, 4 pp, Standard Pressed Steel Co.
366—Self-Locking Capscrews, 4 pp, Klincher Kapscrew Inc.

MOTORS, ENGINES AND CONTROLS
363—Fractional Hp Motors, 6 pp, Westinghouse Electric Corp.

ELECTRICAL, ELECTRONIC COMPONENTS
352—In-Line Readouts, 16 pp, Burroughs Corp.
353—Explosionproof Condulets, 60 pp, Crouse-Hinds Co.
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351—Stainless Steel Tubing, 20 pp, Sumitomo Shoji New York, Inc.
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FASTENING AND JOINING
301—Self-bonding Silicone Rubber
307—Neoprene Contact Adhesive
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MOTORS, ENGINES AND CONTROLS
309—Pump Drive Motor
329—Low Speed Generator

ELECTRICAL, ELECTRONIC COMPONENTS
305—Limit Switch With Neon Light
315—Thermal Time Delay Relays
317—Magnetic Pickup
320—Weldable Strain Gage
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323—Compact Relay
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328—Magnetic Reed Switch
330—Digital Voltohmmeter
331—Silicone Rubber Tape
332—Precision Wirewound Potentiometer
333—Toggle Switches
335—18-amp Rectifier

HYDRAULIC, PNEUMATIC EQUIPMENT
304—Centrifugally-cast Tubes
308—Teflon Seal Ring
309—Pump Drive Motor
313—Dual Valve Assembly Interlock
314—Automatic Flexible Valve
316—Low Pressure Cylinders
318—Miniature Directional Valves
324—Low Capacity Pumps
334—Teflon Lined Rubber Tubes

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2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
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8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
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12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
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REPRINTS

P76	P77	P78	P79	580	581	582	583	584	585	586	587
588	589	590	591	592	593	594	595	596	597	598	599

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7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
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11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
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REPRINTS

P76	P77	P78	P79	580	581	582	583	584	585	586	587
588	589	590	591	592	593	594	595	596	597	598	599

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Key No.	Specific Product

INDEX OF PRODUCTS ADVERTISED IN THIS ISSUE

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the attached READER SERVICE CARD.

A

Actuators
  Mechanical 10, 81

B

Bearings
  Ball 38, 69, 88
  Needle 69
  Roller 69
  Sleeve 73
Bellows 31
Belts, Timing 71
Boosters 86

C

Cabinets 82
Castings 30
Castings, Precision Investment 32
Chains
  Bead 82
  Roller 71, 73
  Silent 71
Clutches
  Mechanical 37, 71
Compressors 80
Computers 5
Cords 87
Counters 79
Couplings
  Mechanical 71, 75
Cylinders
  Hydraulic 86
  Pneumatic 86

D

Decalcomanias 87
Die Castings 11, 36
Drafting
  Machines 22
  Supplies 22, 29, 78, 85, 86
Drives
  Variable Speed 71

E

Enclosures 76

F

Fastening Methods ..... 2nd Cover
Film, Plastic 40
Fittings, Hose, Pipe and Tube 28, 84
Flexible Shafts 86
Furniture, Engineering Department 82, 85

H

Heating Units 13, 83

I

Instruments
  Mechanical 72

M

Magnesium Alloys 74–75
Metal Forming 76, 80
Moldings
  Rubber (see Rubber Parts)
Motors, A-C
  Fractional 18–19, 23
  Integral 26–27
Motors, Air 80
Motors, D-C
  Fractional 23
  Integral 26–27
Motors, Hydraulic 7

N

Name Plates 87
Nuts ..... 2nd Cover

P

Plastics 73
Pumps
  Air 33
  Liquid 7, 33
  Vacuum 80

R

Relays 78
Reproduction Equipment 22
Reproduction Supplies 22, 29, 78, 86
Rod Ends 88
Rubber ..... 4th Cover
Rubber Parts 2, 80, 85

S

Seals 2, 80
Sheet Fabricated 80
Sheets
  Metal 74–75
Silicone Rubber 14
Specialty Fasteners (Pipe Hangers, Special Cold Headed Parts, etc.) 77
Speed Increasers and Reducers 71, 77
Spindles 83
Splines 10
Springs 84
Stampings 82, 84

T

Thermocouples 72
Tracing Paper ..... 3rd Cover
Transformers 84

V

Valves
  Hydraulic 7

W

Wheels 83
Wire 34–35
Wire Forming 82, 84
Wiring Devices 87

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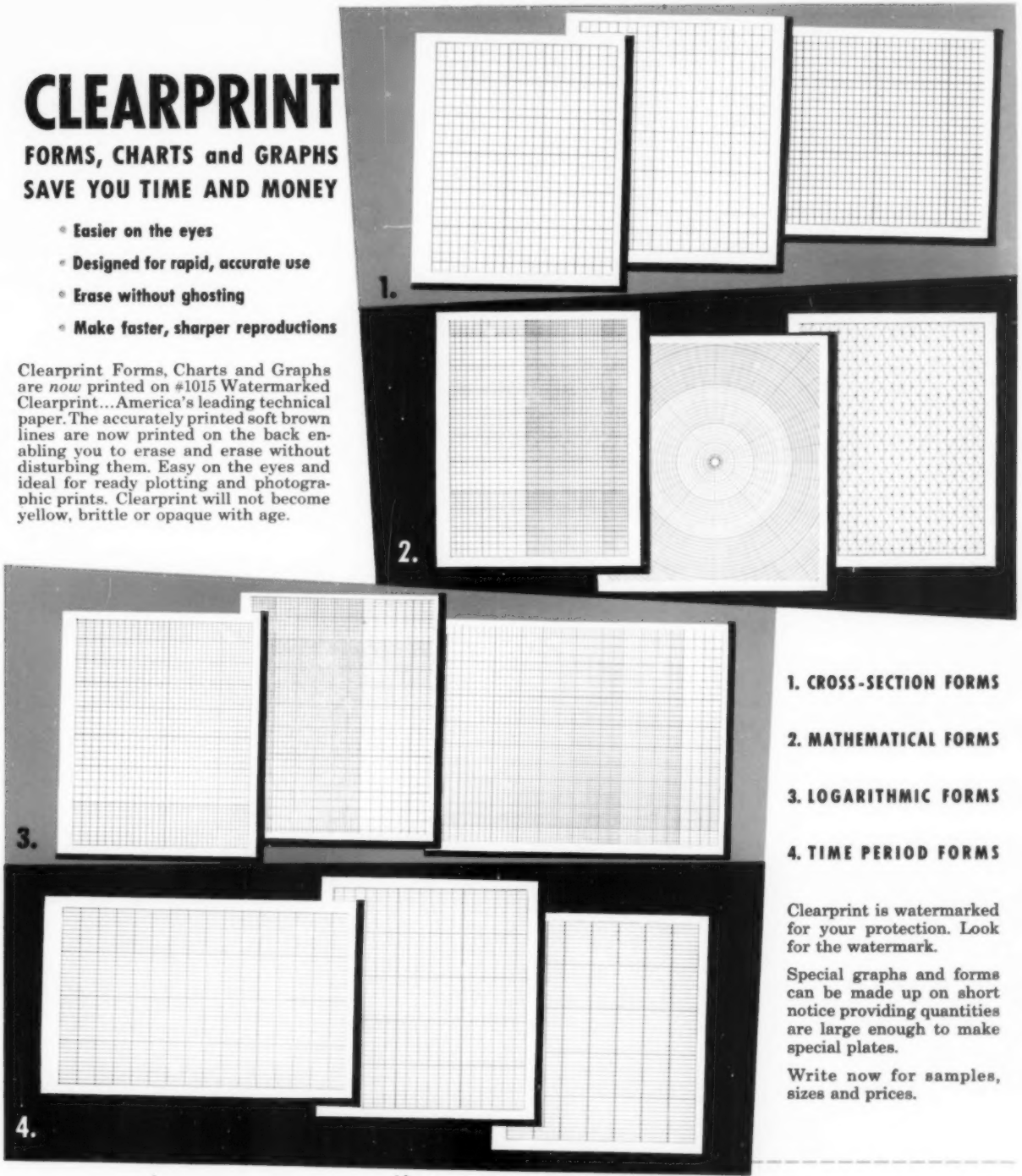

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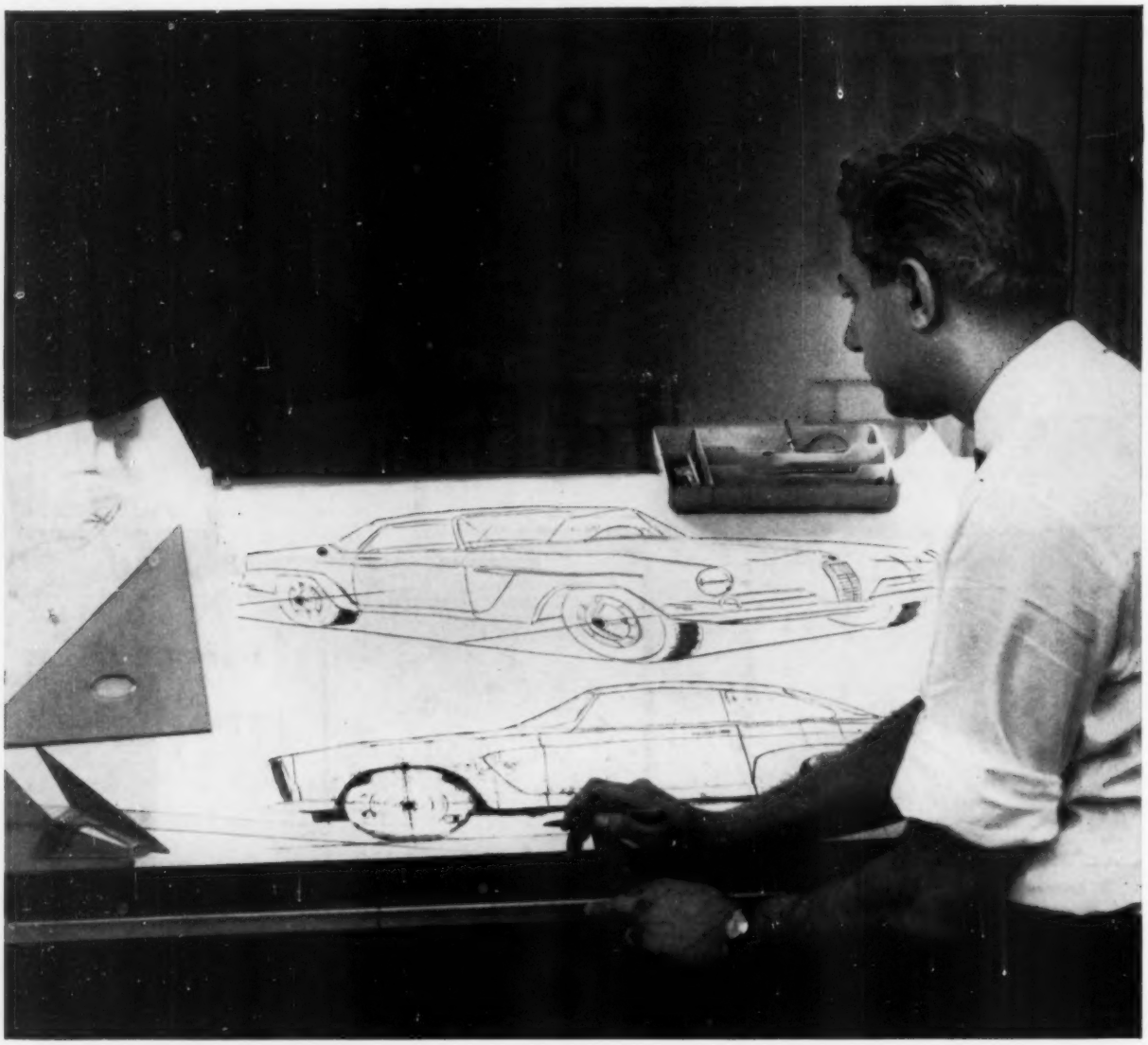

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